Final Technical Report
CRRP2017-09SY-AHMED

UNDERSTANDING THE OPPORTUNITIES AND CHALLENGES OF COMPLIANCE TO SAFE BUILDING CODES FOR DISASTER RESILIENCE IN SOUTH ASIA

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Figure 1. Construction Site, Bangladesh

Project Overview

Project Duration	**:**	One year
Funding Awarded	**:**	US $43,000 for one year (2017/18).
Key organisations involved	**:**	The University of Newcastle, Australia; University of Dhaka, Bangladesh; BRAC University, Bangladesh and Tribhuvan University, Nepal.

Project Summary

This project explores the opportunities and challenges compliance to safe building codes in the current contexts of Bangladesh and Nepal, to achieve increased disaster resilience. Recent disasters in both countries highlight that non-compliance to building codes is one of the significant causes of building-related disasters in South Asia. Increased institutional and community awareness to the importance of safe building codes presents an opportunity to explore barriers and enablers to compliance. Building codes do exist in the two countries, but compliance is generally lacking or limited, especially in the widespread informal building sector. The informal building sector engages in construction which lacks code compliance due to a deficiency in the understanding of or limited access to the codes and/or economic pressures. The project was approached in two stages. Stage 1 involves a comprehensive literature review to identify potential solutions and gaps in terms of disaster resilience. Stage 2 reports on the results of semi-structured interviews and focus group discussions enabling stakeholders to identify a range of challenges and opportunities for facilitating voluntary compliance to safe building codes. The outcomes of the stages are then combined to address the need for understanding how building codes might be more widely adopted to enable disaster resilience.

Keywords: disaster resilience, safe building codes, grey building codes, building code compliance.

Project outputs and outcomes

The project had the following key outputs:

- Global literature review on building codes and disaster resilience.
- Local literature reviews on building codes and disaster resilience in Bangladesh and Nepal.
- An extensive bibliography on literature relevant to the project's topic.
- Three consultative and experiencing-sharing workshops in Bangladesh and Nepal attended by project collaborators and research assistants, as well as key local stakeholders and policymakers.
- Consultations with a wide range of local stakeholders in Bangladesh and Nepal, allowing collection of data for the project.
- "Grey Building Handbook" for low-income, informal sector builders, which can be utilised as an illustrated training manual.

- Translated versions of the "Grey Building Handbook" in Bengali and Nepali, the languages of the project countries.
- A video on the project highlighting and illustrating its key aspects.
- A project website portal through the CIFAL Newcastle website.
- A journal paper based on the project (see Ahmed *et al*., 2018 in the references). Other journal papers are being developed for future publication.

All these outputs have been featured or incorporated within this report.

For a project such as this, most of the outcomes become evident over a period of time, particularly the utilisation of the "Grey Building Handbook" for local level capacity building, and dissemination of the project report to policymakers and stakeholders to improve their work in this field. After project completion, the project video will be uploaded on YouTube and other social media outlets, which will allow understanding its outcome in terms of audience viewing and appreciation. Some of the key outcomes evident in the short term include:

- Capacity building of a number of early career researchers who had very little or no experience in research projects of this nature and scope, which can be expected to contribute to their future research and professional work.
- Inter- and intra-country linkages between universities and researchers, who were not known to each other before – an outcome in terms of forging long-term connections for possible future partnerships and collaborations, both locally and regionally.
- Connections were established with key policymaking institutions in the two project countries, namely RAJUK (Dhaka City Development Authority), Bangladesh, and Ministry of Urban Development, Nepal, both key actors in the field of building codes. Their active interest and engagement in the project workshops indicate potential for them to espouse the project's approach to voluntary compliance in their institutions.

Potential for further work

This project pointed to further research directions to broaden the understanding of the multi-faceted topic of building codes compliance, which includes:

- Developing options for retrofitting or strengthening old buildings, following to the extent possible the construction standards as prescribed in the building codes of the respective project countries.
- Stakeholder and policy mapping for better understanding of possible roles in the integration of building codes and building regulations.
- Exploration of community perceptions of risk and willingness for voluntary compliance, and the incentives and policy environment required for it.
- Developing methods of raising public awareness and the channels and stakeholders that might be effectively involved for that purpose.
- Understanding the role of social media in how it might be utilised to promote widespread compliance to building codes and regulations.

- Investigation of the role of the private sector, and how effective partnerships can be forged between the public and private sectors, and civil society.

Publications

Ahmed, I., Gajendran, T., Brewer, G., Maund, K., von Meding, J. and MacKee, J. (2018). Compliance to Building Codes for Disaster Resilience: Bangladesh and Nepal. *Procedia - Engineering*, 212, 986-993.

Pull quote

"Safe buildings can save lives; tragedies that we have seen in these countries in the recent past need not happen. What is required are building codes that are appropriate and affordable for the vast majority of low-income people in South Asian countries."

- Dr Iftekhar Ahmed, Project Proponent, in an interview by CIFAL Newcastle for inclusion in the project website. See: https://www.newcastle.edu.au/about-uon/governance-and-leadership/faculties-and-schools/faculty-of-engineering-and-built-environment/cifal/projects/projects-apn

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All photographs are by Dr Iftekhar Ahmed unless stated otherwise.

Figure 2. Construction site, Nepal

1. Introduction

1. Project Summary

The intent of this project was to explore the opportunities and challenges of how compliance to voluntary safe building codes can be facilitated in the current contexts of Bangladesh and Nepal (Figures 1 and 2) for increased disaster resilience in South Asia, focusing on two countries of the region: Bangladesh and Nepal. Recent disasters in both countries highlighted that one of the significant causes of the problem lies in non-compliance to building codes. Such disasters have brought institutional and community awareness of the importance of safe building codes, presenting an opportunity to explore barriers and enablers to compliance. Building codes do exist in the two countries, but compliance is generally lacking or limited, especially in the widespread informal building sector. The informal building sector engages in construction which lacks code compliance due to a deficiency in the understanding of or limited access to the codes and/or economic pressures. Thus this project addressed the need for understanding how these codes might be more widely adopted to enable disaster resilience.

Collaboration between four universities; The University of Newcastle, Australia, University of Dhaka, Bangladesh, BRAC University, Bangladesh and Tribhuvan University, Nepal focused on four significant areas:

[1] Sharing the understanding that evidence-based knowledge is a critical component in the commitment to local action

[2] Institutional and community awareness of the importance of compliance with/barriers to enforcement of codes

[3] Fostering communities of collaborative practice

[4] Subsequent development of local and international dissemination networks

Figure 3. Rapidly urbanising contexts of Nepal (above) and Bangladesh (below) with very limited compliance to building codes and regulations

2. Project description

a. Research problem

The generation of scientific knowledge on building and construction continues globally, however the application to disaster risk reduction remains limited. In low-income countries within South Asia specifically, building code frameworks are generally inadequate, reflecting the situation in the case study countries selected for this project – Bangladesh and Nepal. The bulk of buildings in these countries are constructed informally without adherence to building codes and rough estimates indicate that well over 80 percent of housing in these low-income South Asian countries is built using informal construction (UN-HABITAT, 2010; World Bank, 2007). There is very little or no application of building codes in informal sector construction. Even in the very small proportion of formal sector housing, adherence to building codes is generally lacking or limited at best (see Figure 3). Unlike procedures in developed countries, building codes are not well-integrated into building and planning regulations in these low-income countries. Both Bangladesh and Nepal have building codes (DUDBC, 2005; HBRI, 2015), but enforcement and compliance face significant challenges and the codes serve mainly as good practice guidelines. Ultimately, the responsibility for compliance is up to professionals, builders or authorities to follow them.

It is understandable that developing countries such as Bangladesh and Nepal would face constraints in implementing building codes. Beyond the oft-cited issues of enforcement and corruption, affordability is a key constraint for the vast bulk of the population that builds informally. The codes provide good practice guidelines often based on developed country models and can thus be onerous and difficult to implement in the socio-economic context of South Asia. The codes also include guidelines for safety to enable buildings to be disaster resilient – these hazard-related codes can be termed as 'safe building codes' to differentiate them from codes that deal with other aspects of construction (see for example, Library of Congress, 2015). At a bare minimum, if only the safe building codes are followed, a level of disaster resilience can be achieved. To support this process, a 'grey' document or guidance handbook is required, locally contextualised and achievable within the socio-economic constraints of developing countries: a key output of this project. The handbook produced as part of this project includes a set of options to meet varying economic and environmental conditions, and extensively uses visual material for ease of comprehension and communication. The handbook has been translated to Bengali and Nepali for effective local dissemination.

Both Bangladesh and Nepal face disaster risk from various types of hazards including earthquakes, floods, windstorms and landslides. Nepal endured severe earthquakes recently in 2015 (Amos, 2015), where the common adage "Earthquakes don't kill people, buildings do" (Stockton, 2015; UNOPS, 2013) was visibly and tragically apparent. Although Bangladesh has not experienced a major earthquake in recent times, strong tremors often occur, creating public fear (Hannam, 2016; USGS 2012; The Daily Star, 2016); a massive earthquake is a real and significant possibility (Hays, 2016). Bangladesh is also frequently affected by floods and cyclones, for example recently in 2016 by Cyclone Roanu (Australian Broadcasting Corporation, 2016a). Both these countries are also severely threatened by climate change with increasing magnitude and frequency of hazards including new types of hazards such as extreme heat and cloudbursts, likely to exacerbate the impact of disasters. This is a significant global change issue. While earthquakes are not linked to climate change unlike hydro-meteorological disasters (e.g. floods, cyclones), their impacts experienced particularly in cities in a rapidly urbanising world have implications for global change (see for example ESSP, 2006; Steffen *et al.*, 2004). The interpretation of global change aligns with APN's definition as outlined in its 4th Strategic Plan that urban disasters are "human induced processes" and in an increasingly urban

world their cumulative impacts “are significant at a global scale” (Asia-Pacific Network for Global Change Research, 2015).

Disasters exact a severe toll on buildings; in addition to damage and loss of assets in countries that can barely afford them, loss of human lives is most tragic and irreparable. The avoidance of building regulations and the lack of adherence to building codes mean that it does not always require a hazard to result in a disaster – the collapse of the Rana Plaza garment factory in Bangladesh in 2013, killing more than 1,100 people—mainly female garment workers—and injuring another 2,500, illustrates this point (IGLHR, 2014). Such human-induced disasters, often a result of rapid and unplanned urbanisation linked to globalisation, is again a global change issue. Indeed, increasing risk to disasters and climate change impacts is a key aspect of contemporary global change, which this research project explores through the topic of building codes for disaster resilience.

The devastating, and high-profile, disasters mentioned above including the Nepal earthquakes and Bangladesh building collapse have raised local awareness on the importance of safe buildings. They have spurred significant institutional and community interest and activity in both these countries on disaster resilient construction and safe building codes, in the face of public fear and anxiety, as discussed later in the case studies (Chapters 3 and 4). It does appear that there might be an opportunity for voluntary compliance to safe building codes beyond the necessity of policing and institutional enforcement. It is reported in the case studies that some municipalities in Nepal and some real estate developers in Bangladesh are voluntarily following building codes, representing a gradual paradigm shift. It was therefore a relevant and opportune time to undertake this project with the purpose of exploring the research problem relating to understanding the opportunities and challenges of facilitating compliance to safe building codes.

b. Research questions

Given the widespread lack of compliance to building codes in the case study countries of Bangladesh and Nepal and consequent disaster impacts leading to a growth of interest in safe building codes, a key exploratory research question and sub-questions were identified.

Key Research Question:

How can compliance to voluntary safe building codes be facilitated in the current contexts of Bangladesh and Nepal for increased disaster resilience?

The following Sub-questions - were framed to deliver an answer to the main research question:

- **What are the strengths and weaknesses in terms of disaster resilience of building codes globally, and specifically in the project countries?**
- **What knowledge and insights can be gained from institutional and community stakeholders in the project countries on opportunities and challenges for facilitating compliance to safe building codes?**
- **What practice-and-policy guidelines are required to facilitate voluntary compliance and implementation of safe building codes?**

The research problem is complex, multi-faceted and deeply entrenched in socio-economic, political and cultural conditions and has taken root over a long period of time. To address these issues would require social transformation of a profound nature, and at this point in time perhaps only the small beginnings of such transformation are evident. The research therefore does not provide quick-fix and easy solutions, but identifies a probable and plausible trajectory for the small beginnings of social transformation that may realise a greater and more widespread voluntary compliance of safe building codes over the long term.

c. Rationale for context focus

Within the Asia-Pacific region, South Asia stands out in terms of low economic and human development; after Sub-Saharan Africa, it is the least developed region in the world (UNDP, 2015; World Bank, 2016). The region is also highly vulnerable to disasters (Gaiha *et al.*, 2010). A quarter of the world's population live in South Asia (World Bank, 2016) and it is one of the most densely populated regions of the world, compounding the significance of undertaking research in this region.

The impacts of disasters in the smaller South Asian countries are pronounced and recovery difficult because of their lower socio-economic development compared to the largest South Asian country, India (Sarma, 2015). The scope of this research project is focused on some of the smaller South Asian countries, namely Bangladesh and Nepal, but offers lessons relevant to the wider region. Transfer of lessons and cross-learning can be achieved between these countries due to the great extent of similarity in socio-economic conditions. Some of these countries including Bangladesh and Nepal are disaster hotspots and recent events have instigated an interest in safe building codes, therefore allowing cross-learning between nations to achieve disaster resilience.

d. Objectives

- Review global and local literature in the project countries including building codes and regulations to identify potential opportunities and gaps in terms of disaster resilience;
- Engage in consultations with key stakeholders at institutional and community levels to understand challenges and opportunities for facilitating voluntary compliance to safe building codes;
- Produce practice-and-policy guidelines for facilitating voluntary compliance and implementation of safe building codes extending to informal sector buildings;
- Involve early career researchers in the project countries to meet the above objectives and thereby build local research capacity;
- Explore possibilities of forming networks and cross-learning between the project countries and wider regional and international knowledge dissemination.

3. Methodology

The methodology employed a qualitative exploratory research design, linked to the main research question:

How can compliance to voluntary safe building codes be facilitated in the current contexts of Nepal and Bangladesh for increased disaster resilience?

To answer this question a qualitative exploratory methodology was adopted as it assists to "develop as thick and rich as complete an account of the phenomenon under investigation" (Quinlan, 2011, p. 420). The intent of this research is well aligned with such an approach given it explores the subjective experiences and realities of specialist practitioners to understand the phenomenon.

The research methodology was approached in two stages with the intent to understanding safer building codes adoption in two South Asian countries, Bangladesh and Nepal:

Stage 1 involved development of a comprehensive literature review. Both academic and grey literatures were reviewed to identify potential solutions and gaps in terms of disaster resilience.

Stage 2 involved semi-structured interviews and focus group discussions to identify a range of challenges and opportunities for facilitating voluntary compliance to safe building codes.

To seek answers to the main research question, a set of descriptive sub-questions were posed allowing discovery of the nature and characteristics of the phenomenon explored by the main research question. The descriptive studies employed a range of empirical methods including case studies, interviews, focus group discussions and project workshops, utilising participatory and consultative data collection tools. The stakeholder consultations in the project countries and project workshops were prime vehicles for employing these methods and tools.

The empirical stage of the project was substantial, and informed and complemented by literature reviews at different levels including global and local. Because of the exploratory nature of the research, the global literature review was also exploratory and cast a wide net to capture inter- and transdisciplinary perspectives. However, the specific nature of the project with its focus on the built environment and disaster resilience allowed defining the boundaries of the literature review. At the

local level, the literature reviews were more focused on the specific topic of building codes in the project country contexts.

Activities undertaken

The project consisted of the following key activities to achieve the project outcomes:

- At the project outset, the University of Newcastle (UoN) team in Australia undertook a global literature review. Although focusing on the developing world context, the review also examined the challenges encountered and strategies adopted to integrate building codes into the regulatory framework more widely, particularly safe building codes. The global literature review is included in this report in Chapter 2.
- Concurrently, the project partners – University of Dhaka (DU) and BRAC University (BU) in Bangladesh and Tribhuvan University (TU) in Nepal – built up a local database of literature on building codes, including national building code documents.
- The status of the above activities was presented and analysed at an 'Introductory Workshop' in Kathmandu, Nepal on 8-10 November 2017 (Figure 4), a project workshop allowing formulation of strategic tools for stakeholder consultations and data collection in the subsequent stages of the project (see appendix).
- The project partners undertook institutional and community stakeholder consultations and data collection in their respective countries to identify opportunities, challenges and options for promoting safe building codes, particularly in the informal building sector, using tools developed together with UoN.
- An 'Interim Workshop' was then held in Dhaka, Bangladesh, on 23-25 April 2018 (Figure 5). This project workshop was held to review the findings of the stakeholder consultations and data collection, identify achievements and gaps, and plan for subsequent activities (see appendix).
- Deriving from the discussions and feedback at the 'Interim Workshop', the project partners finalised their country reports. These reports are included in this report as case studies (see Sections 2 and 3) and informed the production of this final report.
- Based on the country reports and global literature review, a "Grey Building Handbook" was produced by the UoN team, targeted specifically for the informal building sector in the project countries. The handbook was translated into and published in Bengali and Nepali for dissemination locally in the two project countries. The handbook is included with this report as an appendix.
- A final project workshop was held in Pulchowk Campus, Institute of Engineering, Tribhuvan University, Lalitpur, Nepal on 28-30 August 2018 (Figure 6), where the findings of the project from the three countries – Australia, Bangladesh and Nepal – were presented and

reviewed, and future long-term planning was carried out. Filming was also undertaken for production of a video on the project. The first day included presentations on the three country reports, as well as the draft final report. The "Grey Building Handbook" (see appendix) was also launched, including the translated Bengali and Nepali versions. There were also high-profile presentations from the Ministry of Urban Development and the Dean, Institute of Engineering, Tribhuvan University, Nepal. The second day involved long-term planning beyond the project conclusion including publications, participation at conferences and further research collaborations. There was a field visit the third day to earthquake-devastated areas on the outskirts of Kathmandu, where reconstruction projects were ongoing, particularly the UN-Habitat supported project in the historic city of Bungamati. A regional workshop in the future to share the project's findings was planned and support for that will be sought from the World Bank, following from preliminary communications.

- A website dedicated to the project was created through the CIFAL-Newcastle Centre for Resilience and Sustainable Development, and the project deliverables are freely available from this website for wider dissemination (see: https://www.newcastle.edu.au/about-uon/governance-and-leadership/faculties-and-schools/faculty-of-engineering-and-built-environment/cifal/projects/projects-apn). In addition, the project activities were reported on the CIFAL-Newcastle website (see appendix) and widely promoted.
- A dissemination video has been produced and will be made available on YouTube and also uploaded on the project website.
- A research paper derived from the project was presented at the 7th International Conference on Building Resilience, Bangkok, 2017, and published in a peer-reviewed journal (Ahmed, I., Gajendran, T., Brewer, G., Maund, K., von Meding, J. & MacKee, J. (2018) "Compliance to Building Codes for Disaster Resilience: Bangladesh and Nepal", *Procedia - Engineering*, vol. 212). Other publications are in the process of being produced.
- Possibilities are being explored based on the interest indicated by the World Bank and CIFAL Newcastle to support and help run a wider regional workshop as part of a dissemination strategy and to seek future research opportunities.

Figure 4. Introductory project workshop held in November 2017 in Nepal

Figure 5. Interim project workshop held in April 2018 in Bangladesh

Figure 6. Final project workshop held in August 2018 in Nepal

4. Project relevance

Relevance to APN's Fourth Strategic Plan

The project relates to APN's Fourth Strategic Plan (2015-2020) by promoting cooperation between APN member countries to address a serious global change issue— disaster risk—and generate benefits in terms of regional knowledge-sharing. Disaster risk is a global change issue linked to climate change and human activities altering the earth's surface, hence relevant to APN's mission. As discussed below, the project addressed all the four areas of APN's Action Agenda:

- The project responded directly to one of the key areas of APN's Research Agenda—Risk Reduction and Resilience—and focused on two low-income disaster-vulnerable countries in the Asia-Pacific, Bangladesh and Nepal. Australia is also an APN member and for this project, Australia collaborated with the other two member countries in this regional research project. Although this project focused on the specific field of the built environment, the nature of the research involved interdisciplinary collaboration between architecture, construction management, engineering, law and social sciences, and transdisciplinary collaboration by linking academia with civil society, government agencies and the private sector (e.g. real estate developers). While bearing a relationship with some of the indicative research topics in the 'Risk Reduction and Resilience' key area, such as revisiting current disaster risk management strategies and integrating disaster risk reduction in regional (and urban) planning, this project offers a unique research topic for APN to broaden its portfolio.
- The Capacity Development Agenda was an important element in this project in several ways. Firstly, it produced guidelines informed by safe building codes that will be applicable for training of local construction workers and informal sector builders, and more broadly of personnel from government agencies and NGOs involved in the disaster resilience field. Secondly, early career researchers were engaged in all three project countries, providing a valuable capacity building opportunity through working on this regional and international research project. Finally, the involvement of CIFAL Newcastle—with its own strong capacity development agenda—meant that the project outcomes will be utilised for wider training and exchange of learning. CIFAL is engaged in other capacity building initiatives in several countries in Asia and also in the Pacific region, therefore the findings of this project will support regional capacity building beyond the project countries. Additionally, the World Bank

is expected to support a regional workshop to disseminate the project results, which will also promote and contribute to regional capacity building initiatives.

- In line with activities suggested by APN that meet its Science-Policy Agenda, this project sought new ways of working between technical/scientific, institutional and at-risk communities, and enhance local research and policy through a multi-country endeavour. The project activities developed knowledge to inform policy for advancing resilience, also serving as a platform for a range of stakeholders to contribute to the knowledge development process, very much in line with the examples of activities under APN's Science-Policy Agenda. The research teams have strong connections with government institutions in both the project countries and were able to benefit from these links by including the policy community as an integral part of the research.
- In terms of APN's Communication and Outreach Agenda, this project had a strong focus in this area overlapping with its capacity development activities. The 'grey' building handbook on safe building codes (see appendix) is an example of how the project related to the agenda's overall target of producing "tailor-designed information". The project undertook communication and outreach activities at different levels, targeting local researchers and built environment professionals, government agencies and NGOs, and informal builders and construction workers. The basic premise of regional collaboration between three APN member countries was a powerful communication and outreach initiative. Involvement of UNITAR's CIFAL Newcastle and the World Bank's Global Facility for Disaster Risk Reduction (GFDRR) allowed communicating the project's outcomes to a wider regional and global audience.

Relevance to global change and sustainability

Disaster resilience is of high level policy concern in both Bangladesh and Nepal because of the frequent and various disasters that impact these countries. Bangladesh is one of the few countries in the world that has a Ministry of Disaster Management and Relief dedicated to disaster risk reduction with a key policy instrument in this regard, the 'National Plan for Climate Change and Disaster Management (2016-2021)' (Ahmed *et al.*, 2015) and the 'National Plan for Disaster Management (2016-2020)' (MoDMR, 2016). Nepal has a Disaster Management Section in the Ministry of Home Affairs and a 'National Strategy for Disaster Risk Management' (NSDRM) 2009 (MoHA, UNDP & ECHO, 2008). Nepal repealed the Disaster Risk Reduction and Management Act 2017 (NDRR&M Act).

The NDRR&M Act specifically focuses on protecting public life, public and private property, natural and cultural heritages, physical properties and minimising the disaster risk which shows the importance of building codes for disaster risk reduction, thus this present research project has potential for informing national policy. However, in Bangladesh the issue of building codes is dealt with by the Capital Development Authority (RAJUK) under the Ministry of Housing and Public Works, and although there are recent concerns in Bangladesh regarding building codes for disaster resilience, the building codes are not coordinated with the national disaster management policy. There is thus the possibility of facilitating coordination between policies for disaster risk reduction and safe building practice. In terms of safe building codes, both governments of Bangladesh and Nepal require significant and extensive inputs to translate their policy instruments in practice particularly to address the widespread informal sector and addressing potential disaster impacts and resilience strategies for

at-risk communities. Thus, the timing and scope of this project is relevant to both country contexts as policymakers and national institutions are faced with the challenges of implementing, mainstreaming and rolling out nationwide policy processes. The project is also opportune because of recent commitments made by both countries to the global Sendai Framework for Disaster Risk Reduction (2015-2030).

In the UN's Sustainable Development Goals, disaster risk reduction is emphasised, particularly in Goal 11 on 'Sustainable Cities and Communities', where clearly the link between disaster risk reduction and sustainable development is articulated (UN, 2015). For any developmental initiative to be sustainable, investments into resources, assets and institutional and community capacity need to be safeguarded, so that disasters do not undo the progress made by the initiative. The processes of sustainable development and disaster risk reduction are inextricably linked. This project was founded on this premise.

Furthermore, the project aligns with the views of key global change programs such as ESSP (2006) and IGBP (Steffen *et al.*, 2004), involving a range of human activities, in addition to anthropogenic climate change—such as urbanisation and land-use patterns—that are altering the earth's systems. These anthropogenic changes lead to disaster risk, requiring resilience to withstand and adapt. Additionally, the project relates to the UN's global agendas including the Sendai Framework for Disaster Risk Reduction and Sustainable Development Goals, both promoting safe building practices. The project links with the World Bank's global 'Building Regulation for Resilience' program and the disaster risk reduction mission of UNITAR's CIFAL Newcastle, which are part of global networks.

Figure 7. Urban density, Japan

2. Results & Discussion

SECTION 1: Global overview on disasters and building codes

Nations around the world are subjected to natural hazards that vary in magnitude and nature and unfortunately, the incidence of devastating disasters is increasing (Hillier & Nightingale, 2013). In the last decade alone, more than 6300 disaster events were recorded with approximately fifty percent transpiring in Asia (IFRC, 2015; ADRC, 2016), a region with multiple developing countries where disaster impacts are often severe (Ahmed *et al*., 2018).

Scientific evidence has shown the link between climate change and the increasing frequency, intensity and magnitude of extreme weather-related disasters (Intergovernmental Panel on Climate Change, 2012). However, climate change extends to a wider range of human activities that are altering the earth and its ecosystems, including land-use change and urbanisation (Steffen *et al.*, 2004) (Figure 7), subsequently increasing vulnerability to disasters particularly in regions with ineffective land use planning systems (GFDRR, 2015).

Earthquakes provide a key example: while the causes of earthquakes may be natural, their impacts are more significant across human built environments particularly where compliance to safe building codes is lacking (UNISDR, 2010). Similarly, massive migration and congestion of urban centres often occurs without corresponding urban planning regulations, which compound these impacts (GFDRR, 2015). Ultimately, the outcome of many disaster events can be traced to societal decisions in relation to land use planning and building systems: development location and construction techniques. Conversely, building and planning regulations are considered a powerful tool in the attempt to increasing community resilience and reducing risk in relation to disaster events (Bernicat, 2015; World Bank, 2015).

e. Promoting change

Due to global concern regarding the increase in environmental hazards, nations around the world have come together under various international platforms to find collective ways of solving the problems faced in the built environment and other sectors. Agreements made on such a level are adopted and contextualised to adapt to the unique needs of countries and their communities. The United Nations (UN) has been at the frontline of major global decisions and since the 1990s has focused on disaster risk reduction (DRR) when it declared the 1990s as the International Decade for Natural Disaster Reduction (JICA, 2017). Subsequently, the UN developed several strategies for DRR with the Hyogo Framework for Action 2005 (HFA), considered one of the first major international accords to demonstrate an ongoing commitment to this area (UNISDR, 2007). The HFA has since been superseded by a more robust global commitment and a 15-year plan of action: the Sendai Framework for Disaster Risk Reduction (UNISDR, 2015a). The Sendai Framework, within its wider global resilience agenda, clearly articulates the importance of safe building codes and within its Priority 2 entitled “Strengthening disaster risk governance”, it states:

“To encourage the establishment of necessary mechanisms and incentives to ensure high levels of compliance with the existing safety-enhancing provisions of sectoral laws and regulations, including those addressing land use and urban planning, building codes, environmental and resource management and health and safety standards, and update them, where needed, to ensure an adequate focus on disaster risk management” (UNISDR, 2015a, p. 12).

Recently, the international commitment has been further shown through the United Nations Sustainable Development Goals (SDGs) (United Nations, 2015). The SDGs identify targets that recognise the importance of DRR (UNISDR, 2015b). One such target is to support least developed

countries - through financial and technical assistance – to construct sustainable and resilient buildings utilising local materials (UNISDR, 2015b) in which building codes may be a mechanism to assist in achieving this target.

Other global strategies run in tandem to the abovementioned, and importantly, further highlight the need to address the complex and fragmented system of planning and building code compliance. As an example, the 'Resilient Cities Campaign', managed through the United Nations Office of Disaster Risk Reduction (2010), has identified that for earthquake events, poorly built buildings are unable to withstand seismic shocks, are more prone to collapse and result in most deaths. Similarly, poor construction combined with unsuitable development locations exposes communities to the full force of many natural hazards including tsunami, cyclone and flood events (UNISDR, 2010). In this manner, UNISDR stated that a key element to building resilient cities is to: "Apply and enforce realistic, risk compliant building regulations and land-use planning principles" (UNISDR, 2010, p. 8).

Along with the UN, prominent international development agencies such as the World Bank, United States Agency for International Development (USAID) and Japan International Cooperation Agency (JICA) have also attempted to address the global priority of resilient buildings and are promoting the uptake, compliance and implementation of safe building codes (JICA, 2016; USAID, 2016; World Bank, 2015). As the GFDRR (2016) aptly states: "Building code compliance saves lives" (p. 2).

5. Building codes

f. Origins of building codes

The Code of Hammurabi is considered one of the earliest records that refer to building law (Encyclopaedia Britannica, 2018). Established by King Hammurabi (1792-1750 BCE) of Babylon, the laws made reference to construction with provision for remuneration of builders and their liability in case of damages and collapse. The laws— considered rather barbarous today—require, for example, that the builder or his son be executed if a building collapses and kills the owner or his son (Johns, 1903). Other literature sources trace the origin of building codes to the Great Fire of Rome around 64 A.D. (Cote & Grant, 1988). The Roman Empire had undergone rapid development which led to increased construction including apartment buildings with little attention being paid to the quality of construction and the materials used. The fire was subsequently attributed to poor construction practices and this brought forth a new master plan that was, importantly, 'enforced' to avoid any future events (Cote & Grant, 1988; Caryl, 2014).

Although various forms of codes were adopted over the years, the Great Fire of London in 1666 introduced significant change. Following this devastating event more than 13,000 buildings were destroyed as the city was left in ruin, which was attributed to rapid fire spread from combustible construction materials. Consequently, building codes were introduced that considered fire prevention for life safety and property protection, setting a precedence for many codes today (London Fire and Emergency Planning Authority, 2018). Over the decades new codes have been introduced and existing codes amended following other major disaster events —for example the San Francisco earthquake and fire of 1906 and the Chicago fire of 1971—to aid in protecting the public (NCGBCS, 2016; Cote & Grant, 1988).

g. Defining building codes

Building codes and regulations are important for disaster risk reduction and adaptation to climate change (World Bank, 2015). Cote and Grant (1988) explain that "A code is a law or regulation that sets forth minimum requirements and, in particular, a building code is a law or regulation that sets forth minimum requirements for the design and construction of buildings and structures." (p. 53).

Early commentary often defined building codes as the requisite provision and order needed for the construction and maintenance of buildings. Such versions of codes were mainly concerned with health and safety; however, they were gradually expanded to include a wider set of requirements as we know today (Bergeron, 2008; NCGBCS, 2016). The Australian National Construction Code (NCC) provides an example that aptly demonstrates the comprehensive nature of contempory policy:

"The National Construction Code provides the minimum necessary requirements for safety and health; amenity and accessibility, and sustainability in the design, construction, performance and liveability of new buildings (and new building work in existing buildings) throughout Australia. It is a uniform set of technical provisions for building work and plumbing and drainage installations throughout Australia whilst allowing for variations in climate and geological or geographic conditions." (ABCB, 2018).

Although building codes and regulations are often used simultaneously, they are significantly different in meaning and scope. The broader term 'building regulations' as in developed countries often refers to both land-use planning and building codes (World Bank, 2015). However, in many countries such as Australia, there is a division between building codes and regulations, where building codes relate to technical building provisions or construction requirements (ABCB, 2018) and regulations concentrating on administrative processes such as building and planning permits (see for example, New South Wales Environmental Planning and Assessment Act, 1979).

What is important is that the integration of building codes and regulations has been advantageous in minimising the impacts of disasters. Their importance as a mechanism by which to protect life and build community resilience has become the focus of countries more recently (UNESCAP, 2012). Japan provides a prime example: the country maintains some of the world's strictest codes, yet it has taken more than seven decades, and a series of disasters, for Japan to reach this stage (Glanz & Onishi, 2011).

However, the situation is vastly different for many developing countries where building codes are often not mandatory (see for example, Thiruppugazh, 2008). Bangladesh has a National Building Code, yet it has been explained that "the Building Code is not an independent legislation or act, rather it is a national level approved document" (HBRI & BSTI, 2006). In addition, within developing countries it is widely reported that enforcement and compliance of codes face serious barriers which add further complexity, including ineffective governance and corruption (GFDRR, 2014), resulting in vulnerability to disasters.

h. Prescriptive and performance based codes

Building codes may be categorised as prescriptive or performance based. Prescriptive regulations are standards created to describe how buildings should be constructed. They specify objectives, processes and often materials required to achieve the desired regulatory goal (Cote & Grant, 1988; Gann *et al.*, 1998). However, prescriptive regulations are generally inflexible and often impede innovation (Greenwood, 2007). Introduced to address some of the shortcomings of prescriptive regulations, performance-based codes differ as they provide a more flexible approach. Performance-based codes have objectives set out, however they offer the opportunity for innovation, creativity or consideration

of cultural and heritage value. This flexibility allows for alternative solutions to be developed to suit the individual building requirements: achieving the same regulatory goal, but through a different perspective (Cote & Grant, 1988; Gann Wang & Hawkins, 1998).

6. Disaster resilience within the informal sector

The inherent link between disasters and housing types that are more resilient has been well established (see for example, Gautam *et al.*, 2016) where it is widely cited that disaster events present an opportunity for building future resilience (Birkmann *et al.*, 2010; Haigh & Amaratunga, 2011; Manyena, 2013). In fact, many country-specific guidelines and initiatives for safer buildings have arisen following major disasters (Bernicat 2015; see for example ERRA, 2006; NHDA, 2005).

In the project countries, Bangladesh and Nepal, recent disasters have been triggers for institutional consideration of the importance of building code compliance. In Bangladesh after recent building disasters, particularly the collapse of the Rana Plaza garment factory in 2013 killing over 1,100 and injuring many more people (Australian Broadcasting Corporation, 2016b; IGHLHR, 2014), the Bangladesh National Building Code was reviewed and updated, and there are moves to make the policy mandatory and enforced through a new regulatory authority (HBRI, 2015). Similarly in Nepal, after the recent Gorkha earthquakes 2015 which killed over 8,790 people, 22,300 injuries and more than half a million buildings collapsed (PDNA, 2015). The national building code (NBC) of Nepal is in a review process and the government declared NBC mandatory and made the local governments responsible for enforcement.

However, a large proportion of buildings continue to be constructed informally without permits; therefore, the application and regulation of codes is not enforced. Within many developing countries, built-up urban centres and peri-urban areas are often associated with large informal settlements. Dobson, Nyamweru, & Dodman (2015) highlight that globally, a large percentage of the most vulnerable populations live in informal settlements. These communities are often home to the urban poor and their circumstances leave them vulnerable and exposed to various hazards (Prayoga & Imtiaz, 2017).

Housing development within the informal sector often consists of uncoordinated construction processes, erratic development patterns, and can exist on environmentally vulnerable land, or often on vacant private land that lacks legal title (Fernandes, 2011). Fernandes (2011) argues that building development in the informal sector are the results of long existing traditional processes and practices of land acquisition, tenure and building. Furthermore, there is a growing realisation that regularisation rather than eviction is the right approach to ensuring safety within these communities. To increase disaster resilience a different approach is also required for ensuring safety and capacity building within this context. The extension of lessons from building code compliance in the formal sector to the informal sector context has been identified as a positive move in the safe building codes agenda (Fernandes, 2011).

i. The importance of traditional knowledge

Human interaction with the physical and social environment over the years has formed the basis and foundation of traditional knowledge (Zhang, 2015). Traditional buildings— buildings constructed based on customary knowledge and expertise—constitute a large portion of structures in developing countries. Their prevalence is due to cost effectiveness of traditional construction and also the promotion of local skills, culture and native materials (see for example Gautam *et al*., 2016).

According to Fujieda & Kobayashi (2013), the growing interest in the use of indigenous knowledge in construction further facilitates resilience and independence of vulnerable communities.

It must be acknowledged that the informal sector is not totally devoid of rules and processes for development, but the absence of the formal procedures of conventional development is what constitutes the informality. Khalafzai & Nawaz (2017) claim that "Unequal power dynamics between western science and TK [traditional knowledge] have undermined the potential role that traditional knowledge-holders can play as active participants in many fields including DRR" (p.39).

Fortunately, the current advocacy to recognise the knowledge and expertise of indigenous people in planning reinforces social rights and justice, and assists creating resilience (Fernandes, 2011). According to the Asian Development Bank (2013), finding a middle ground in the establishment and enforcement of building codes through a participatory approach gives higher certainty of achieving the desired results. In many ways this is aligned with the term 'procedural justice' as conceptualised by Murphy (2017) which encourages willingness to comply with regulations due to identification with the authority and reduced negative sensitivities.

7. Building code compliance

According to Le Grand (2005), "Compliance is the act of following the rules" (p. 2), it is the level of adherence to the law (Australian Government, 2013).The concept of compliance is not limited to the development and enforcement of regulations, but a social transformation where organisations and communities appreciate the benefits of safe codes and follow them willingly: aptly termed by Johnson (2011) as a "compliance culture" (p. 27). In other terms, compliance is centred on the premise that people are inspired to do the right thing and/or follow stipulated rules for personal gain through thorough assessment of possible penalty and consequences for non-compliance (Murphy, 2017).

According to Burby and May (2000), two major and conflicting philosophies address the issue of compliance; the use of deterrence and facilitation. The deterrence approach includes frequent inspection and severe sanctions involving financial penalties for non-compliance. While facilitation involves more of a flexible and collaborative approach to compliance and involves incentives and technical assistance (Burby and May, 2000).

Burby and May (2000) explain that "The general idea here is that by lowering the costs of compliance (i.e. facilitating compliance) and by rewarding good behaviour while reserving punishment for recalcitrant 'bad apples' who consistently violate code requirements, a regulatory climate will be created that fosters voluntary compliance" (p. 3). These forms of compliance have also been categorised as: enforced compliance, deterrence, and voluntary compliance (Australian Government, 2013).

j. Types of compliance

Enforced compliance

Enforcement is quite simply undertaking government activities that compel adherence to regulatory requirements (Australian Government, 2013). Enforcement activities may involve:

1. Inspections
2. Fines
3. Prosecutions (Australian Government, 2013).

Deterrence

Deterrence is aligned with enforcement; however, it relates to "the act or process of discouraging actions or preventing occurrences by instilling fear or doubt or anxiety" (Australian Government, 2013, p. 8). This form of compliance includes:

1. Increasing the likelihood of exposing non-compliant citizens
2. Penalties for non-compliance (Australian Government, 2013).

Voluntary compliance

Voluntary compliance differs from the former two methods as it involves a willingness to voluntarily comply with the regulatory requirements, rather than being compelled to comply (Australian Government, 2013). Voluntary compliance is often self-motivated. People willingly choose to follow stipulated rules to fulfil moral obligations (Murphy, 2017). Voluntary compliance is often a measure of:

1. An understanding of the need for the regulatory requirement
2. Confidence that the theory validating the regulation is sound
3. Assurance that compliance will lead to the desired results (Australian Government, 2013).

k. Code compliance in developed countries

Developed countries have continued to improve building codes and regulations in response to hazards, structural failures and health disasters (GFDRR, 2016). Japan and Australia provide two case study examples. Both countries share a heavily regulated building sector where code compliance is mandated.

Building code compliance in Japan

Japan is known for its vulnerability to various hazards and likewise for its strict building codes—and how they may be applied to assist in improving public safety within the built environment. Japan provides an important case study as it was initially similar to many developing countries in terms of its poor construction quality and limited technical knowledge (WBDRMH, 2017). However, through gradual change to the legal and policy system, the country has created one of the most rigorous frameworks that achieves a high level of building safety. In this manner, Japan serves as a model for those countries wishing to strengthen local policy to assist building resilient communities.

Within the current system in Japan there are three predominant laws in force: Building Standard Law (BSL), the Fire Service Law and the City Planning Law. While the former two are primarily concerned with life safety (and associated property protection), the latter relates more to the creation of liveable cities (Okasaki, 2007). Importantly, the building codes within the BSL are enforced throughout the country on a national level, with consideration for structures, fire and equipment (Okasaki, 2007). In addition, they are performance based building codes (Okasaki, 2007) to allow for flexibility in design and construction.

The building approval and regulatory procedure in Japan presents a staged system: design (preparation of drawings), construction commencement, construction, completion and building occupation. Within the design, construction and completion stages there are requirements for approvals to be obtained (certification) from the regulatory authorities (Figure 8) (Kamemura, 2016; Okasaki, 2007). Although a formal and comprehensive system of regulation exists, it is worth noting

that the system is subject to change: most recently this has involved inclusion of ‘Start of occupancy’ and ‘Owner’s periodic reporting’ levels (Kamemura, 2016).

The World Bank Disaster Management Hub (WBDMH) (2017) identified ten lessons from Japan’s regulatory system that may be considerations for those in developing nations:

1. “Regulation should be understood as a tool to guide and support the safety of the built environment and should not be seen principally as a means of exerting control.
2. To develop an effective approach to building safety, countries need a clear understanding of their available human, technical, and financial capacity.
3. Effective regulation takes place within an enabling environment that includes education, financial incentives, and other mechanisms designed to proactively support compliance.
4. The regulatory ecosystem must make professional expertise and technical services available to all who wish them.
5. Formal regulatory systems should recognize prevalent construction practices, including non-engineered construction, and the risks associated with them.
6. An effective regulatory regime is based on science and requires the participation of academia.
7. Governments can strengthen their regulatory regimes by coordinating action with the building industry.
8. The private sector can play an important role in effective enforcement of building regulation, but only where mechanisms for oversight, fairness, and conflict resolution are robust.
9. Financial incentives can play a key role in promoting safety and overall quality in the built environment.
10. An incremental, context-specific approach – one in which policies are based on analysis of data accumulated over many years and events – is the path to a safer built environment” (WBDMH, 2017, pp. 2-4).

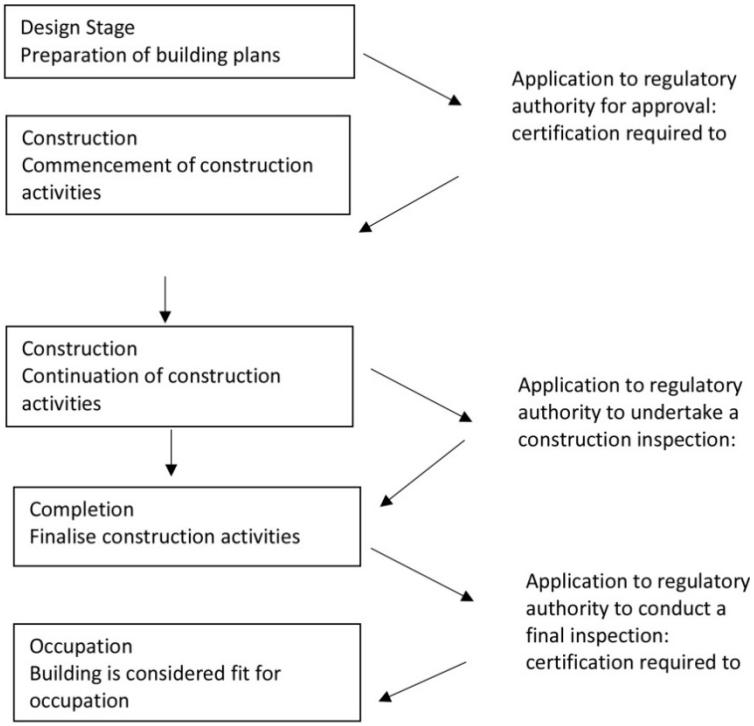


Figure 8. A summary of the building regulatory process for Japan (adapted from Okasaki, 2007, p. 5).

Building code compliance in Australia

Australia presents a slightly different perspective. Within Australia the different States and Territories maintain individual planning legislation that relates to the National Construction Code (NCC): the technical building provisions. Although the legislative process of obtaining building permits, inspection regimes and so forth may differ in States and Territories according to their planning legislation, the NCC is the standardised document providing uniform requirements with minor variations depending upon geographical conditions. When compared to most developing countries, Australia has a high building code compliance rate and according to the Australian Building Codes Board the high rate of compliance is due to a shift towards performance based over traditional prescriptive based building code requirements that were introduced in 1996; whereby, such provisions provided flexibility in the selection of products and methods of construction (ABCB, 2018).

Essentially the NCC is a performance based code where it has overarching performance requirements that must be complied with. However, compliance may be attained by complying with the provisions 'clauses' set out within the document, by development of a performance solution or a combination of both methods. While compliance with the Performance Requirements within the Code remains mandatory, there is the ability to consider innovative construction, heritage buildings, as well as advances in technology and materials (ABCB, 2016). The present NCC is divided into multiple volumes to address the needs of different development types covering a range of themes (Figure 9):

- Volume One: Building Code of Australia (BCA) Class 2 to Class 9 Buildings (aligned with high-rise residential, commercial and industrial)
- Guide to Volume One
- Volume Two: Building Code of Australia: Class 1 and Class 10 Buildings
- Volume Three: Plumbing Code of Australia (ABCB, 2016)

The policy system surrounding implementation of the NCC is complex and as noted, differs across the States and Territories; however in each case, drawings are assessed by a regulatory authority, permits are required before construction work can commence, regulatory inspections must be undertaken during construction and upon completion of works a final inspection and certification must be obtained prior to building occupation.

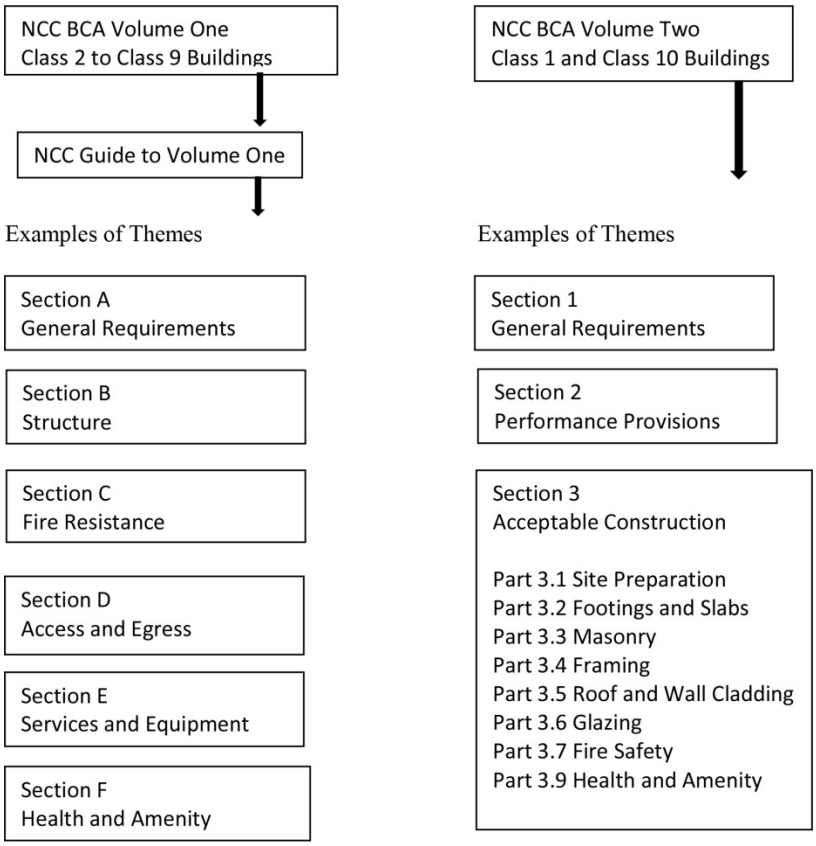


Figure 9. Examples of NCC content relative to development type
(Adapted from Australian Building Codes Board, 2016).

l. Code compliance in developing countries

As formerly noted, building and planning regulations are seen as a powerful tool to increase community resilience in relation to disaster events (Bernicat, 2015; World Bank, 2015). According to GFDRR (2016), the low level of sophistication of regulatory frameworks in developing countries places them in a less favourable position when it comes to enforcing building codes and regulations. The key issue being that many of the building codes in developing countries have been adapted from developed countries (Johnson, 2011; World Bank, 2015), but being poorly implemented, often dysfunction and with a frequently top-down approach, the codes prove difficult to implement in the socio-economic conditions of the developing world (GFDRR, 2014).

Developing countries are known for a high level of informality in the building sector and the case is not always due to the absence of regulations, but low level of compliance that is often due to factors such as inadequate monitoring, transparency and an ineffective legal system. Furthermore, corruption,

favouritism and poor enforcement impede compliance in the developing world (GFDRR, 2014). Beyond the structural issues in developing countries, researchers and organisations have attempted to ensure safety in informal settlements by regularisation and creation of standard and resilient structures with traditional knowledge (Fernandes, 2011). The following examples briefly consider Kenya and Turkey (as highlighted in the GFDRR 2014 report) in relation to the issues that have resulted in poor construction practice and unfortunately resulted in devastating impacts following a disaster event. The case of Peru provides a different perspective: an illustration of strategies employed to help increase resilience within the built environment.

Building code compliance in Kenya

Within Kenya, the building code regulatory system was derived from colonial standards and as such maintained a hierarchal top down approach. Primarily, it was a combination of urban planning and in terms of the codes 'affordability' that resulted in policy implementation failure. With many of the population unable to access standardised construction materials due to cost, the policy system of the development sector essentially collapsed (GFDRR, 2014)

Building code compliance in Turkey

Turkey had formulated a rather comprehensive building code that included earthquake provisions; however, the implementation system failed as violation of code requirements became commonplace: disregarding technical requirements and building additional 'unapproved' levels, for example. Corruption was also identified as a contributor to the system which exasperated poor practice. These activities had a devastating impact upon local communities during the 1999 earthquake where more than 17,000 people died, and 65 percent of residential units were deemed non-compliant (GFDRR, 2014).

Building code compliance in Peru

Peru, like many Latin American countries is characterised by widespread informal settlements. The country worked in collaboration with the Intermediate Technology Development Group (ITDG) (now Practical Action), an international and non-governmental organisation, to focus on providing affordable housing for the poor through the provision of building materials, construction technology, employment and sources of livelihood (Majale, 2004). Following the 1990 earthquakes, ITDG introduced a participatory reconstruction project to assist residents with building earthquake-resistant buildings. The organisation worked closely with community members and local contractors by educating them on innovative technologies for earthquake resilience (Majale, 2004).

Attempts to ensure safety within such communities included the land titling programs which started in 1996 (Fernandes, 2011) and supports from ITDG. Although lack of title has been a major issue associated with informal settlements and the associated vulnerability, a review of titling across the country revealed that the process has not solved the deeper causes of vulnerability within the settlements. There has not been a significant investment in infrastructure in those areas, neither are residents granted access to credit (Fernandes, 2011). Ultimately, the titling program has created opportunities for informal landowners to obtain legal titles for their residences.

The systemic issues in developing countries is multi-faceted, however, strategies and attempts to empower the most vulnerable have been associated with a level of success as evident in Peru. However, despite the shortcomings of the program, the assurance and security of land ownership may potentially facilitate better construction practices.

8. Encouraging code compliance

The World Bank Disaster Management Hub (WBDRM) (2017) argues that:

"Building regulation has a crucial role to play in reducing disaster risk. Building codes can lessen vulnerability by specifying adequate standards for exposure by guiding development away from the most hazard-prone areas" (p. 1); and that "[b]y incrementally raising building standards and working to create effective regulatory compliance mechanisms, developing countries can save lives, protect housing and other assets, and contribute to an overall safer built environment" (p. 1).

An effective building code regime requires a legal and administrative framework at the national level, with building code development and maintenance processes and implementation at the local level (World Bank, 2015). By learning from the experiences of developed countries, developing countries can reach a high level of maturity in reinforcing and complying to building codes (GFDRR, 2016).However, adaptation is required to ensure compatible for the local context to ensure implementation success (World Bank, 2015).

Yet in developing countries where non-compliance is common practice and enforcement low, the question is raised as to how code compliance can be encouraged. The following factors suggested by UNESCAP (2012) outline a range of issues for consideration when investigating mechanisms to encourage compliance:

1. "Keep it simple
2. Raise awareness
3. Provide incentives
    a. Offer special housing loans
    b. Relax zoning restrictions
    c. Offer tax breaks
4. Attack the issue from all sides
5. Transfer responsibility to the private sector" (pp. 14-15).

In many respects these elements are straightforward and may assist in creating a compliant society; however, UNESCAP (2012) saw the need to go beyond high order statement and review in terms of a local level application. Subsequently, UNESCAP (2012) proposed that the following five factors must be considered within the local context when considering how to encourage compliance:

1. Financing: financial incentives are acknowledged as a mechanism by which to encourage compliance. Through such incentives, it is possible to make immediate sectoral change; however, this factor requires large capital, resources and a conforming political context.
2. Human resources: building capacity across the sector between all stakeholders assists with awareness, understanding, and ultimately, compliance. There is a need for all stakeholders involved in the building cycle to have knowledge of the codes and consequences for non-compliance. This extends to those responsible for regulation (e.g. council), implementation (e.g. engineers, builders) as well as owners and buyers.
3. Enforcement capacity: traditionally the regulatory authority has been responsible for enforcement activities and compliance is attained in countries where governance is generally

strong. However, where government enforcement capacity is limited alternative regulators may assist with encouraging compliance (e.g. banks, insurance agencies).

4. Stakeholder cooperation: for successful policy implementation and compliance, cooperation amongst stakeholders is essential. UNESCAP (2012) states that '*enforcement is most effective and efficient if government takes the lead…*' (p. 16). However, cooperation extends beyond the government entity as the community and construction industry needs to be involved and supportive: to raise awareness around the importance of regulation for human safety.
5. Other contextual factors: the individual characteristics of a place, combined with political and economic situations need to be considered when determining measures to encourage compliance. By understanding the context, the most suitable mechanisms can be employed to encourage compliance (UNESCAP, 2012).

m. Facilitation mechanisms

Key drivers for encouraging building code compliance in developing countries were highlighted by World Bank (2015) to include:

Improving legitimacy and procedural justice: The bulk of work here lies on the shoulders of enforcement officials. Procedural justice involves fairness, trust and open communication that assist building relationships and encourage compliance.

Designing regulatory processes to support compliance: by striking a balance between enforcement and compliance support may foster transparency, respect and limit resistance. In addition, building capacity and encouraging compliance can be considered in terms of seven points of intervention to:

1. "Establish a sound legislative and administrative foundation at the national level.
2. Develop a building code suitable to local social and economic conditions that facilitates safe use of local building materials and practices.
3. Strengthen implementation of building codes through plan review, site inspection and permitting at the local level.
4. Support code compliance, provide advisory services in addition to inspection and enforcement.
5. Take advantage of opportunities for regulatory interventions.
6. Clearly identify hazard zones and restrict development according to exposure.
7. Advance supporting institutions" (World Bank, 2015, p. 80).

n. Reviewing compliance challenges

Building codes and regulations are primarily for the safety of people, despite this however, compliance to these codes and regulations is yet to reach its optimum levels. GFDRR (2015) suggests that non-compliance is a bigger problem in developing countries and this is often caused by a range of factors including low income level, unaffordability of formal housing stock and deeper social and institutional issues within those countries.

According to the World Bank (2015), some of the key issues are:

1. Ineffective land use system: allowing settlements within high risk zones.
2. Weaknesses in building code administration and institutional capacity: incorporating insufficient resourcing to enable effective regulation.
3. Insufficient legislative foundation: national legislative deficiencies and issues associated with implementation.
4. Unaffordable compliance costs for the poor: lack of consultation with local level agents creating unrealistic standards.
5. Insufficient recognition of prevalent building practices: regulations often do not consider that building is staged to accommodate funding and material availability.
6. Dysfunctional regimes of building controls: inspection activities are often complex and an economical burden increasing overall costs.
7. Corruption and regulatory capture: results in reduced safety standards.

9. Conclusion

Safety in the built environment is a priority for governments and the essential purpose of building codes and regulations. However, codes are of no use if there is a low level of compliance, hence the examination of the various subjects that relate to building codes and compliance with a brief comparison of practices in developed countries and developing countries was undertaken in this project. The brief literature review has highlighted systemic irregularities, lack of legitimacy and procedural justice as key issues impeding compliance in developing countries and not necessarily the absence of codes. Furthermore, attention is drawn to the need for more contextualised codes that addresses the issues associated with the traditional means of construction and informal settlements.

The following sections provide backgrounds and case studies of building codes (or lack of) and the results for buildings and population in Bangladesh and Nepal. The case studies assessed the views of various stakeholders on the issues and challenges surrounding safe building codes for ensuring disaster resilience.

Figure 10. Informal housing, Bangladesh

SECTION 2: Case Study: Bangladesh

Bangladesh, a densely populated South Asian country, is highly vulnerable to different types of hazards (flooding, riverbank erosion, cyclones, drought, landslides, earthquakes, building collapse, etc.). Dhaka, the capital city, is centrally located and is an economic, social and cultural hub. Large migration takes place from rural areas of Bangladesh to Dhaka for employment and other opportunities: currently the city accommodates nearly 20 million people. In order to host this huge population, over two hundred thousand buildings have been constructed—often in a haphazard manner—rendering them highly vulnerable to different hazards (Figure 10).

The Bangladesh National Building Code (BNBC) and the building and planning regulations of the Dhaka Development Authority (RAJUK) are the key instruments for ensuring building safety. The Bangladesh case study consists of attempts to assess various stakeholders' opinions in Bangladesh on the issues and challenges of compliance to safe building codes for ensuring disaster resilience. Twenty-two individual stakeholders (academics, professionals, engineers, masons, etc.) were interviewed to assess their experiences with building codes in the city. In addition, four Focus Group Discussions (FGDs) were undertaken, involving a range of stakeholders including private companies and construction professionals such as masons. The stakeholder/expert interviews revealed that:

- Those who are involved in the city's construction activities are in most cases not aware of the BNBC.
- Landowners were found to be reluctant in implementing the BNBC, as they are not willing to expend the additional costs for building construction.
- Workers involved in building construction were not found to be interested in compliance to codes as there remains no incentive to comply.
- There remains no government authority that actively promotes and monitors the implementation of the BNBC.

The incorporation of the BNBC into university and trades-school curricula can be promoted to provide proper training to built environment professionals and relevant others. In addition, continuous dissemination of the BNBC through different media (TV, radio, newspapers, etc.) is required.

Figure 11. Map of Bangladesh, image courtesy of Mapcruzin.com

(http://www.mapcruzin.com/free-maps-bangladesh/bangladesh_sm_2008.gif)

10. Geography and population of Bangladesh

Bangladesh—a South Asian country with a population of 160 million—records the highest density (around 1200 persons per km^2) in the world and is highly vulnerable to different types of natural and man-made hazards. Physiographically, the country's significant part (nearly 80%) consists of low lying floodplains (Brammer, 2012). Geologically, the country is located in the active margin of the Indian and Eurasian tectonic plates. Thus the entire north-south elongated eastern part of the country is vulnerable to earthquakes. In addition to the existing natural risks, a significant number of man-made hazards (building collapse, fire incidences, etc.) are also of great threat. As rural areas lack sufficient employment and other opportunities, people migrate to cities, particularly to Dhaka, the capital. Although the urbanization level currently is still low (around 30%), by 2050 it is expected that almost 50% of the population will be living in urban areas (Islam, 2005).

Dhaka (Figure 11) is centrally located and is considered the hub of economic and socio-cultural activities. The city currently accommodates nearly 20 million people (UNDESA, 2017), while it records nearly 70% of the total urban population of Bangladesh. The city's density is over 40,000 persons/km^2 (Islam, 2005; Kabir *et al*., 2018) and has experienced phenomenal growth in the last few decades, while in some wards of Dhaka South City Corporation (DSCC) the density exceeds over

200,000 per km^2 (Islam, 2005). In order to accommodate this large number of inhabitants, the city has been developed in a very unplanned and haphazard manner. More than two hundred thousand buildings have been constructed in the city mostly without maintaining the building regulations, posing a risk for most of the city dwellers. Poor urban planning, excessive population density and presence of an informal settlement population of over four million has exacerbated the conditions (Angeles *et al*., 2009).

11. Impacts of disasters on buildings and people in Bangladesh

Dhaka has already experienced several large-scale building collapses and fire incidents where thousands of people have been severely affected. Therefore, it is pragmatic to ensure the application of compliance to safe building codes. In addition, due to rapid unplanned and unregulated urban expansion, Dhaka suffers from problems associated with lack of rainwater drainage, leading to flooding during the monsoon season. The city experienced destructive flooding events in 1987, 1988, 1998 and 2004 mainly due to excessive rainfall (Dewan *et al*., 2007), severely affecting a large number of city dwellers and their dwelling units. Localised water build-up in the rainy season in different parts of Dhaka is a regular phenomenon due to inadequate drainage, filling up of water bodies and extensively built-up areas. Therefore, it is important to ensure compliance to safe building codes to enable resilience and reduce such devastating impacts.

According to a recent survey of a national daily newspaper, about 78,000 buildings out of 326,000 in Dhaka have been identified as vulnerable to disasters (Sarker, 2009). It is often reported that an earthquake with moderate intensity can produce a significant havoc of building collapse. Due to non-compliance to building codes, the city has faced a number of devastating disasters within the last couple of decades. These have included building collapses, fire conflagrations and earthquake impact. In all cases, non-compliance to the building codes have compounded the impacts, resulting in significant property damage and unfortunately large death tolls. Among all the disasters experienced by Dhaka, the collapse of the Rana Plaza garment factory (2013) has been the most devastating, killing over one thousand people, with non-compliance to building codes contributing significantly to its collapse.

o. Major fire incidences in Dhaka

In Dhaka, fire is becoming an unmanageable threat particularly in high-rise buildings mostly constructed in a manner that violates the national building code. Various incidences of major fires in different types of buildings are described below.

Fire incidence in Nimtoli, Old Dhaka

A severe fire broke out in the densely-populated part of Old Dhaka city at Nimtoli on 3rd June 2010 (Figure 12). The flames gutted eight buildings and over 20 shops, and killed 120 people at Nawab Katra of Nimtoli, and resulting in injury to approximately a further two hundred people: most of the affected people were women and children. Initially it was thought that explosion of two transformers at Nimtoli started the fire, but it was later found that the fire originated from an oil stove and spread to nearby chemical warehouses and resulted in the high casualty figures and damages (Imam, 2010).

Figure 12. Building fire in Nimtoli, Old Dhaka, 2010. Image: Anisur Rahman, Courtesy of *The Daily Star*

It has been identified from this incident that an absence of urban planning or deviation from codes was a contributing factor to the devastation. Moreover, the density of the residential area affected made it difficult for firefighters to quell the blaze. The narrow lanes of old Dhaka and staircases of old buildings made it difficult for fire services to enter the area. Thus, casualties increased due to non-compliance with RAJUK setback regulations (Imam, 2010).

Fire at Japan Garden City

On 12th February 2010, an acute incidence of conflagration in Japan Garden City (Figure 13) occurred as a consequence of residential and office building construction that had inadequate fire management provisions: violating the BNBC. In one of the buildings of Japan Garden City, seven members of a family lost their lives when fire lit up in the tenth storey of the building. There were only a few fire extinguishers and water hydrants serving the building and unfortunately it was identified that no occupants were able to operate the equipment nor were they in working order. Even after a charge was levelled at RAJUK, no response was received on how this building was approved to be built with such inadequate fire management systems (The Daily Star, 2010a).

Figure 13. Building fire in Japan Garden City 2010, Image courtesy of *The Daily Star*

p. Major building collapses in the last decades in Dhaka City

Begunbari building collapse

On 1st June 2010, a five-storey residential building suddenly collapsed at Begunbari, Dhaka. The building was adjacent to shanty dwellings, and unfortunately the collapse impacted this area and the collapse also impacted them. Tragically, 25 people died as a result of the collapse with more and more than 50 people were injured (refer Figure 14) (The Daily Star, 2010b).

Figure 14. Begunbari building collapse 2010. Image courtesy of *The Daily Star*

From the way in which the building collapsed, it was evident there was no proper plan for the building, nor any rule or code was followed in its construction. Furthermore, it was identified that workmanship and engineering as well as the materials that went into the making of that building were also of very poor quality contributing to the devastation. An improper site had been for selected for its construction as the land had been filled using garbage instead of soil. Additionally, some heavy construction materials had been stored on the top floor of the building, which contributed to the collapse. Another major factor was that the foundation was not designed properly and the connection between the columns and the base was not adequate (The Daily Star, 2010b).

Spectrum sweater factory collapse

On 11th April 2005, the seven-storey Spectrum garment factory collapse took place at Palashbari in Ashulia, a suburb near Dhaka (Figure 15). The building was designed for 4 storeys, but 9 storeys had been built (Institute of Engineers Bangladesh, 2007). The building was constructed on soft soil on swampy land, using poor quality building materials, resulting in the whole design being faulty and non-compliant. An explosion of a boiler on the ground floor was also a contributing factor to the collapse. About 73 workers were killed and more than 85 were seriously injured (Institute of Engineers Bangladesh, 2007).

Figure 15. Spectrum sweater factory building collapse 2005. Image: Zahedul I Khan, courtesy of *The Daily Star*

Phoenix garments factory collapse

On 25th February 2006, a six-storey commercial building collapsed in central Dhaka at Tejgaon (Figure 16). This building collapsed mainly due to structural failure. The building was originally constructed as a commercial building; however, in 2005 it was converted to a 500-bed hospital. The

main reasons behind the collapse include unplanned construction, poor building materials, and non-compliance to RAJUK regulations and BNBC (The Daily Star, 2006).

Figure 16. Phoenix garments factory building collapse 2006. Image: Anisur Rahman, courtesy of *The Daily Star*

Rana Plaza building collapse

On 24th April 2013, 'Rana Plaza', an eight-storey garment factory building, collapsed in Savar, a suburb of Dhaka. The collapse of this building is considered to be one of the deadliest garment factory accidents in history, as well as the deadliest structural failure (Figure 17) (The Daily Star, 2018).

The building has become a symbol of poor compliance concerning workplace safety and security in Bangladesh's industrial sector, and an icon of poor attention to the working conditions in garment factories in developing countries. According to the Bangladesh Garment Manufacturers and Exporters Association (BGMEA) nearly 4,000 workers were in the building at the time of the collapse. After over a month of search-and-rescue operations, a death toll of 1,134 and 2,500 serious injuries were listed (IGHLHR, 2014; Australian Broadcasting Corporation, 2016b; The Daily Star, 2018).

The main reason for collapse of this building was attributed to structural failure, again, a result of non-compliance to RAJUK laws, building codes or other regulatory requirements of Bangladesh.

Figure 17. Rana Plaza building collapse 2013. Image courtesy of *The Daily Star*

The building was originally designed for 5 storeys; however, a total of 8 storeys were constructed. The building was also converted from a commercial use to industrial with no additional provisions for safety. It was constructed on a pond filled with loose material which compromised its structural integrity. The use of substandard building materials, aggravated by vibrations due to the generators inside, was a further reason for such devastating damage.

12. Building regulations in Bangladesh

q. Bangladesh National Building Code (BNBC)

In Bangladesh, the BNBC was first drafted in 1993, but not until recently the process of formally reviewing or updating the codes has taken place. In 2006 the Building Construction Act was amended to include a new section 18A, and on 15 November 2006 it came as a gazette empowering the government to promulgate the building code as a legally binding document. In December 2009 the House Building Research Institute (HBRI) involved leading experts from Bangladesh Road Transport Corporation (BRTC), Bangladesh University of Engineering and Technology (BUET), Bangladesh Standards Testing Institute (BSTI) and outside to update the code and act within a year and then made it available to all. In 2016 its latest edition was published as a draft copy which has not been gazetted yet. According to HBRI, it is expected to have this edition gazetted by 2018.

The purpose of the Bangladesh National Building Code is to establish minimum standards for design, construction, quality of materials, use and occupancy, location and maintenance of buildings within Bangladesh in order to safeguard, within achievable limits, life, health, property and public welfare (HBRI & BSTI, 2006).

The provisions of the code apply to the design, construction or occupancy, alteration, moving, demolition, repair of any building or structure and to any appurtenances within or connected (HBRI & BSTI, 2006). It is stated that the provisions of the code are applicable to all persons of Bangladesh.

Since 2006, the code has been made mandatory for compliance with any building construction under the Building Construction Act of 1952, to ensure accountability in the management of overall building construction and safety of the buildings. According to section 2.1 of chapter 2 of part 1 of the BNBC 1993, the government is under obligation to establish a new, or designate an existing, agency for the enforcement of this code within a given area of jurisdiction. However, the government is yet to establish such an agency. Thus, there is an absence of a regulatory authority responsible for all safety aspects of buildings as per BNBC and this remains a major concern. Section 2.6 of Part 2 of the BNBC only states that violation of the code will be an offence and the authorities can take legal action. However, it prescribes no procedure for institution of legal proceedings, which needs to be addressed. The provisions of the Building Construction Act 1952, along with the code need to be updated, taking into consideration the present socio-economic situation of the country.

r. Addition in the new draft edition of BNBC 2010

The 1993 BNBC has dealt with a range of development areas including construction, structure, material, geo-technical and seismic aspects. As evident from section (f), the 1993 BNBC did not include environmental influences on planning, design, construction and selection of construction materials.

In the latest edition of the BNBC (HBRI, 2016), new forms of permit and inspection were introduced. When modifying the building code, the City Development Authority (RAJUK) regulations were also included. Classification of occupation, and definitions and general agreements have been changed and updated through consulting different international codes whereby a range of designs have been considered. Subsequently, types of building construction have been broadly classified into two groups: non-combustible and combustible types. Non-combustible types are further subdivided based on fire ratings. Combustible type is mainly timber or wood-based construction, which is subdivided based on the type of timber (HBRI & BSTI, 2006).

Additional considerations have been introduced or revised to align with combustion types and assist in the construction of safer buildings. The considerations include updated specifications for building materials in the latest edition, with two new chapters on bamboo construction and steel composite structures. Strength specification design for concrete structures has been rationalised and loads on buildings and structures have been updated. Confined masonry has been introduced to the masonry structures chapter to further strengthen structural adequacy of new builds against disaster events. Existing provisions for electric services, building acoustics, sanitary systems, water drainage, and lifts and escalators were thoroughly revised along with provisions on sustainability measures. Guidelines for signage in urban and rural areas have been introduced and standardised environmental graphics and graphics for universal accessibility have been added.

In this new draft, precautionary requirements were modified according to revised building occupancy classification. In terms of disaster situations, specific requirements for fire protection have been introduced and the earthquake load has been revised based on the Euro Code and the Indian Code. Furthermore, provisions for environmental protection and high-rise buildings are now included with minor changes made to storage, handling practices, and supply of fuel and gas.

Significant revisions have addressed current climate change concerns. In the original 1993 Code, the calculation of basic wind speed was based on the fastest speed. In the new 2016 draft edition, this figure has been amended to '3-second gust speed' which is about 11 percent higher than the basic wind speed. In Dhaka, formerly a figure of 210 km per hour was employed, and this has been updated to reflect that it is now about 236 km per hour. Similarly, there are plans to increase wind pressure by 4 to 5 percent. The seismic design category is included in the code as it is most vital for structural design and relates to the soil conditions. In the new draft edition, the whole country is divided into four different zones with every building in zones 3 and 4 to be designed as 'Special Moment Frames' to handle movement during earthquakes. From the amendments and proposed changes to the new draft, it is evident that significant emphasis is being placed upon building codes to minimise severe impacts from disaster events and ultimately protect life. The next phase of this process may involve consideration of a regulatory authority to assist with compliance, and importantly, education to raise awareness of the safer building codes.

s. Land development rules for private housing 2004

The Land Development Rules for Private Housing is a legal instrument for controlling land development in the private sector housing. The rules provide procedures and guidelines for land development protecting the environment. They detail the percentage of land that must be kept for community facilities, amount of land to be sold out, school sites, road hierarchy, and importantly, planning standards including, for example, the allocation of land per 1000 persons. In RAJUK there are very few planners working in large cities such as Dhaka. There has been consideration given to the establishment of decentralised zonal RAJUK offices that divide the city into different zones.

According to the government's Comprehensive Disaster Management Programme (CDMP), almost 65% of the structures in the city are built on soft land acquired by filling up water bodies. The majority of these buildings were constructed by both a violation of planning regulations and building codes.

13. Building construction practices in Dhaka

Dhaka is one of the fastest growing cities in the world (Berkowitz, 2013). Rapid urbanisation is currently occurring and the city of nearly 20 million people is growing year by year. Large population growth demands various types of buildings and construction works. Slums, semi-permanent, permanent, single and multi-storey building construction is a widespread scenario in the city for diverse purposes such as residential, commercial, industrial, educational and health. While the widespread informal settlements consist mainly of slums and semi-permanent types for residential use (Islam, 2005; Angeles *et al*., 2009).

Dhaka City Corporation was established as 'Dacca municipality' in 1864. Later it was renamed twice, first in 1983 as 'Dhaka Municipal Corporation' and finally in 1990 it was renamed as 'Dhaka City Corporation'. In December 2011, Dhaka City Corporation divided into two independent city corporations called 'Dhaka South City Corporation' and 'Dhaka North City Corporation'. In fact, in the infrastructural development of Dhaka South City Corporation (older part of the city), most of the

zones were formed more than 100 years ago, where about 95% buildings of this zone were built without adequate construction equipment, proper construction process, within a context of lack of proper urban planning and proper landuse planning. Within these zones most of the buildings were built haphazardly. In some areas of this corporation, some of the buildings constructed over the last few decades appear to follow RAJUK laws, but not those established by the BNBC.

The scenario of Dhaka North City Corporation is relatively better from the perspective of building construction and urbanisation. The North City area was built covering 56 wards and there are about 5 million inhabitants at the northern part of the megacity (Kabir *et al*., 2018). In the recently developed areas within the city corporations, building owners are now increasingly aware of the existing building rules and regulations of the city development authority, as building constructions are gradually being controlled by RAJUK. In older areas it has been observed that the landowners, engineers and planners still remain unaware of the existing building codes and their importance. Ultimately, the landowners are reluctant to spend extra money to achieve compliance with the code requirements.

14. Research approach and methodology

The methodology of this study is linked with the main research question - "How can compliance to voluntary safe building codes be facilitated in the current context of Bangladesh for increased disaster resilience?"

The study was undertaken based on primary and secondary data from different parts of Dhaka. It was decided to focus on Dhaka because of its national prominence.

t. Data collection and analysis

For the present study, primary data collection was carried out though interviews across different relevant institutions and concerned personnel, particularly those with experience on building codes.

Data collection was carried out in 2 stages.

Stage 1 involved semi-structured interviews with key stakeholders who have prior experience with building codes. A total of 22 individual experts/ key stakeholders from various government agencies, autonomous bodies and private companies were interviewed (Table 1, Figure 18 and Table 2). Interviews were recorded and later translated into English.

Stage 2 involved four focus groups discussions (FGDs) (Table 3, Figure 19 and Table 4). FGDs involved contractors, sub-contractors and masons. Discussions were recorded and translated into English.

Data was subjected to thematic analysis - a three-stage coding process to identify themes. Responses have been analysed through coding methods and descriptive statistics

u. Details of interview participants

Table 1. Individual Interview Structure

S. No.	Type of Stakeholders	No. of Interviewees
01	Academic institutions	3
02	Govt. organisations (Management level)	3
03	Govt. organisations (Operations level)	2
04	Private Companies (Management level)	3
05	Private Company (Operations level)	3
06	Civil Work Subcontractor	2
07	Foreperson	2
Total		18

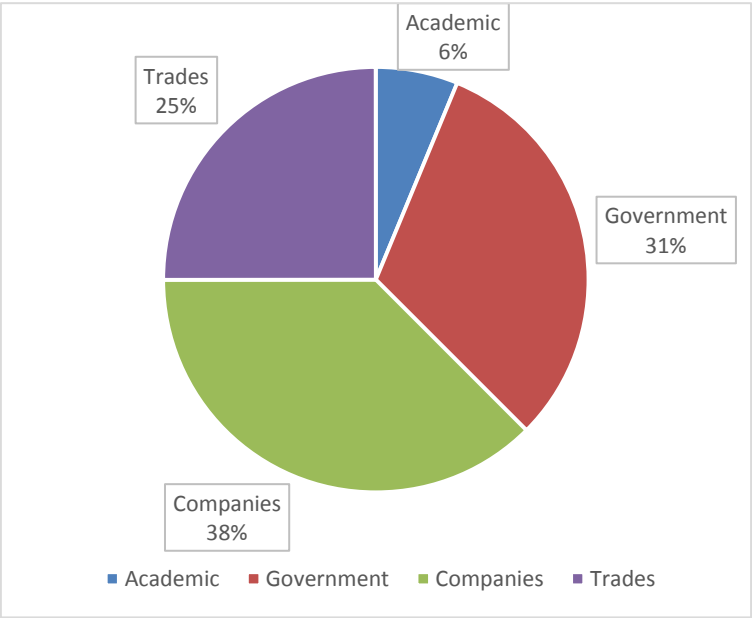


Figure 18. Distribution of Interviewees by type

Table 2. Participant Specialisation

No.	Stakeholders	Specialisation
1	Academics	Earthquake, building construction, disaster prevention and urban safety, seismology, construction vulnerabilities to earthquake hazard
4	Government Authority	Detail Area Plan (DAP) (RAJUK)
5	Government Authority	Disaster and Earthquake Resilience Project (RAJUK)
6	Government Authority	Fire Service and Civil Defense (FSCD)
7	Government Authority	Fire Service and Civil Defense (FSCD)
8	Governmental Authority	House Building Research Institute (HBRI)
9	Construction Company	Mukta Construction Ltd
10	Real Estate Company	Anwar Landmark Company
11	Real Estate Company	ASSET Developments Ltd
12	Developers Company	Durba Developments Ltd
13	Consulting Company	d.Zignscape Consultant Ltd (Structural, Architectural, Soil test Company)
14	Construction Company	Residential Developers Ltd Kochukhet, Dhaka Cantonment
15	Civil Work Contractor	M/S Subarna Enterprise
16	Civil Work Contractor	M/S Madina Construction
17	Civil Foreperson	Freelance

v. Details of focus group participants

Table 3. Focus Group Discussions (FGD) structures

S. No.	Type of Stakeholders	No. of FGDs
1	Masonry Team	3
2	Masonry Union	1
Total		4

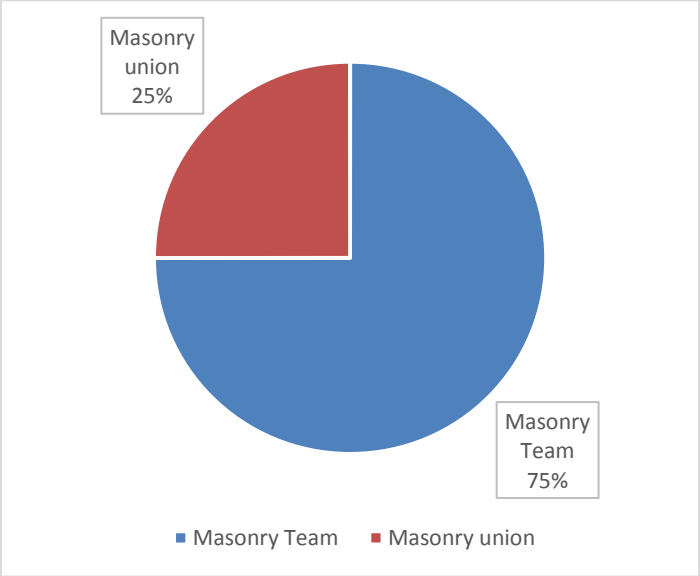


Figure 19. Distribution of Masonry FGD Stakeholders

Table 4. FGD Profile & Locations

S. No.	Type of Stakeholders	Specialty	Study Area
FGD-1	Foreperson & Mason	Civil work and Steel work Foreperson	Sipahibag, Khilgoan
FGD-2	Mason	Civil work and Steel work Mason	Bhuiyapara, Madartek
FGD-3	Mason & Construction Worker	Civil work Mason and Construction Worker	Banasree, Rampura
FGD-4	Labour Union	Foreperson, Mason, Construction Worker, Helper	Meradiya Bazar, Banasree

15. Results – Interviews and Focus Groups

w. Participants' perception on building compliance

For this project, twenty-two key stakeholders from academic institutions, government agencies and private companies were interviewed to identify the issues and challenges related to the implementation of building codes and compliance to safe construction in Dhaka with regard to disaster risk.

The interviewed academics highlighted that only around 10% of buildings in Dhaka comply with the building codes. Therefore, a significant part of the city's buildings have been constructed without following the existing regulations. The government officials mentioned that there is no regulatory body in Bangladesh to monitor whether the building code requirements are being implemented. The review and approval of the building drawings is sometimes undertaken by RAJUK; however, this occurs only after the review by professional engineers and planners. Following the building approval, the construction process is not monitored.

In discussions with private developers, it was stated that building codes are maintained in the larger scale projects. In many cases, the developers also follow the codes' requirements as they have the technical staff and qualified engineers to undertake this role. Private building owners and small construction companies in most cases violate the codes. They do not recruit qualified engineers to avoid higher costs. Private companies may send the materials for testing to relevant laboratories of different government agencies and engineering universities. However, it often takes too long to receive test results, and in some cases incorrect results are received. Given the time delays, private companies identified that they do not wait for the test results and often start construction: in violation of the building codes. Furthermore, private company personnel also reported that a building design may be completed by structural engineers and architects, but in the field the site engineers execute according to the specifications and drawings without giving attention to whether the building compliances are ensured or achieved. It was evident that until recently, there has been no regulatory board for monitoring and implementing the BNBC. In most cases, high-rise buildings, or commercial buildings and other official large buildings are currently constructed according to the building code requirements, but private landowners tend to neglect code requirements to avoid extra expenses.

Through the interviews it was identified that Dhaka's building construction in the past mostly took place without the application of building codes and construction is often done by masons. In the interviews, the masons and contractors/sub-contractors stated that they had never heard about BNBC; rather they used to construct buildings based on the provided drawings and general compliance and site engineering instructions. They also reported that in most cases private landowners construct buildings in coordination with contractors/sub-contractors or the foreperson rather than employing skilled engineers due to higher associated costs.

The masons identified that they do not receive adequate safety measures from the landowners. RAJUK has to monitor the implementation of the building codes, but that is lacking and thus building owners often violate the rules including setbacks and other compliances. Very often, engineers and building owners instruct differently and this creates confusion amongst the masons and subsequently, directed by the building owner's decisions, rules and regulations are not followed.

x. Reasons suggested by stakeholders for non-compliance with building codes

The interviews and FGDs indicated that the existing building codes are not implemented by the building owners during construction. Reasons behind non-compliance were identified by each participant cohort and are summarised below.

Experience of academics

- Absence of proper mindset.
- Lack of awareness among people on building codes.
- Buildings owners' intent to reduce extra expenditure.
- Lack of awareness of codes by some engineers resulting in non-implementation.

Experience of government agencies

- Professionals in the construction sector are not aware of the BNBC.
- The BNBC is difficult to understand because it is written in English. The code employs complex terminologies and is only understood by engineering professionals.
- Lack of internal-organisational harmony, that is, industry fragmentation.
- Building owners are not aware of the consequences for non-compliance of the building codes.
- Many engineers are not acquainted with building codes.
- In general, the wider community, clients and construction workers have little or no idea about building codes and their importance.
- Lack of knowledge of engineers, architects and planners of the building codes and the necessity for compliance.

Experience of private companies

- Misconception on BNBC exists across the construction sector that its application incurs significant additional expense.
- Neglect of building codes by site-based engineers and officers due to a lack of concern about building codes.
- Lack of precise knowledge at all levels regarding building codes.
- Ignorance about building codes and insufficient skills of masons, forepersons and contractors in relation to the codes and administration.
- Many civil engineers do not have clear knowledge about BNBC.
- The issue extends beyond the BNBC: often masons and forepersons do not follow even the construction drawings provided.

- Construction workers do not want to extend effort to understand and apply the codes and their goal is often to reduce the construction period. In an environment where they do not receive safety equipment from the owners, they tend to neglect the codes/compliances.

Experience of the masons (FGD results)

- Masons receive no training on BNBC.
- Major challenges are the inadequate supply of building materials by the owners, differences of opinion between engineers and owners, unavailability of safety products.
- Around 95% of the masons do not have any knowledge on building codes.
- Masons do not receive any incentives or inspiration to adopt the codes, particularly as they work in an environment where they are not supplied with safety materials.
- Extra expenditure is one of the main reasons discouraging building owners to adopt building codes.

16. Measures to encourage compliance

y. Recommendations of stakeholders for voluntary compliance

Many participants identified measures they understood would encourage voluntary compliance to the codes and help construct safer buildings.

Perceptions of autonomous institutions

- BNBC and building compliance need to be included within the tertiary systems: in different courses in university curricula.
- Training programs are required on the importance of building codes for professionals who have already graduated.
- Proper implementation of the land use policy is required. Diverse types of buildings should be built as per allotted specific zone according to land use planning rules.
- Educational institutions need to develop and promote awareness programmes among the private sectors, real estate agencies and general community.

Recommendations of government agencies

- Avoiding complex and jargon language such as engineering terminologies. There is a need to produce plain language publications for easier understanding and use by the general population.
- Several volumes of BNBC are required to be published: including separate topics covered by each volume.
- An educational and awareness programme is necessary to inform people of the benefits of following BNBC and the negative consequences of non-compliance.

- Building owners can be provided with incentives like credit and certificates to encourage them to follow building codes.
- Land use planning also has a vital role to create and construct disaster-resilient buildings. To begin with, sub-soil investigations should be conducted to identify liquefaction potential due to earthquakes, so that risk sensitive land use planning can be undertaken.
- Public awareness should be raised by mass media and other campaigns such as seminars, workshops and mock drills.
- Training should be provided to all relevant professionals including engineers, architects and planners, along with sub-contractors, forepersons and masons.
- Monitoring cells need to be formed as soon as possible so that where necessary action can be taken.
- All new buildings need to be built as disaster-resilient incorporating the BNBC.
- Using land use planning and geo-engineering data new construction must be conducted according to specific zones.
- Provision of incentives can be a strategy. As Bangladesh is a developing country, building owners often find themselves in financial crisis while constructing buildings. Providing soft loans from the House Building Finance Corporation may encourage compliance. There are two elements in constructing a building: Structural drawings and Architectural drawings. An owner should get a loan only when they submit the structural drawings to RAJUK prepared by a professional engineer following the BNBC.

Recommendations of private companies

- All bodies relating to construction need to be concerned about building codes to build safe and disaster-resilient buildings.
- There is a need to train all the key stakeholders through workshops, seminars, TV-radio-newspaper advertisements.
- A bank loan policy should be flexible with nominal interest rates when following the BNBC.
- From the government level there should be a motivation/incentive for the relevant stakeholders.
- Implementing land use planning policy, using different types of construction needs to be considered in terms of specified separate zones.
- To promote the application of BNBC, the approval of a building design complying with the BNBC should be given expeditiously.
- To make people aware of the BNBC, workshops, seminars and training programs should be arranged.
- Different training programs can be arranged not only for the engineers, but also for managers, supervisors, foremen and masons on technical aspects of BNBC rules.
- Booklets, brochures or leaflets should be distributed with detailed and simplified building codes, benefits of following the codes, consequences of not following them.

- Construction workers should be given monetary incentives and training to make them interested in the BNBC.
- Construction to be carried out through proper land use planning.

Recommendations of masons

- RAJUK should formulate, monitor and implement land use planning policy precisely.
- Honest employees should be deployed for monitoring and field visits for the implementation of codes, because monitoring is a key factor in compliance.
- Awareness-raising activities need to be initiated. In this case, documentaries on BNBC can be broadcast on television and radio.
- Masons can be given incentives and certificates for good construction.

17. Recommendations of stakeholders for enforced and deterrent compliance

Suggestions of academics

- Many engineers do not have a professional license for designing or constructing buildings; therefore, their knowledge and skills are limited, yet they are designing and constructing. In this case, monetary penalty can be sanctioned.
- There is no assigned authority from the government side that will approve, monitor, and give occupancy certificate of a building as RAJUK does for Dhaka. The Bangladesh Government should establish such an authority to approve, monitor, provide occupancy certificate, as well as legal action in case of violating the rules.
- If any building is constructed violating building codes, then strong fines or imprisonment should be considered. Gas, electricity, and other services can also be disconnected as penalty.

Suggestions of professionals

- RAJUK is carrying out an urban resilience project. There are two sub components: one is improvement of building code enforcement and another one is implementation. Under this project, an international consulting firm is going to be appointed that will identify mechanisms to promote the implementation of the BNBC. To get building completion certificates/license, building owners need to fulfil some conditions. Otherwise they would not be able to get the license and No Objection Certificate (NOC) from respective authorities.
- A building should not get the electricity supply connection if proper building codes and safety rules are not maintained. Moreover, RAJUK should not provide a building permit unless proper building codes are followed.
- Before commencement of construction when the land owner applies for NOC, then the following factors should be considered as per BNBC:

- Presence of 10-metre wide road in front of the building;
- Availability of sufficient numbers of exits;
- Availability of fire safety plans on each floor;

- Presence of active and passive heating, ventilation and air-conditioning systems;
- Installation of fire doors and fire detectors in the building;
- Availability of adequate water supply for fire extinguishers, training for fire evacuation, and fire drills.

Suggestions from private companies

- The building approval authority has to be transparent to avoid permits being issued through bribes and political persuasion.
- To implement the BNBC, the concerned city development authority must be accountable and transparent.
- The consultant team that designs the building can play a significant role. They should enforce the codes in the execution team (engineers, supervisors, electrician, foreman and masons) and can also inform the building authority about the importance of building codes.
- The structural department of the company should instruct the relevant personnel to follow building codes properly. They should introduce the codes and provide information about the penalties for violating the codes.
- Contractors/sub-contractors and masons should not receive their payment until implementation of code precisely as per design has been done. Persons not following the codes should also be fined.

Suggestions of masons (FGDs)

- Building codes are not followed in Bangladesh when constructing a building because owners encounter financial expenses when following the codes. In some cases, building owners do not want to follow even RAJUK setback rules.
- In 99% of construction sites in Bangladesh, safety is not being practiced. In this case, RAJUK should not issue NOC to permit the owners to commence the construction of the buildings until they assure that required safety measures are available on site. After receiving permission, building owners are not interested in the safety of the workers anymore. Injured workers and families of dead workers usually do not receive any compensation.

8 Key findings and recommendations

z. Key findings

- The building code is now included in the curriculum at the undergraduate level in prominent academic institutions like the Bangladesh University of Engineering and Technology (BUET).
- The general public continues to remain unaware of the BNBC and its importance to life safety.
- A significant number of planners, architects and engineers are not acquainted with the BNBC.

- Building owners are often reluctant to invest additional expenditure for implementing the BNBC.
- Poor monitoring and law enforcement is responsible for the lack of implementation of the building codes.
- In most cases, the stakeholders assume that the code is only used for resisting earthquake events.
- There remains a lack of proper training and awareness of construction workers.
- The code is not followed currently.
- The code is written in English and not easily interpreted by the general community which impacts upon compliance as it is only understood by certain professionals.
- The building codes developed by BUET are not properly understood.
- Malpractices in design and construction of buildings continue to be prevalent.
- Lack of inter-organisational harmony exists amongst the industry.
- Absence of a proper monitoring authority or regulatory board is preventing compliance to building codes.
- Negligence of building codes by the site–based engineers.
- Unavailability of an enforcement mechanism for implementation of the BNBC affects compliance.
- Following building codes from the very beginning can help to avoid significant financial loss.
- Many civil engineers do not have an accurate knowledge of the BNBC.
- Land use planning is not maintained in Bangladesh and it is necessary to enforce rules and regulations to reduce risk.
- Following building codes has the potential to make buildings durable against all hazards, not only earthquakes.

aa. Key recommendations

- Convince owners to follow building codes so that after assessing the building they get a clearance certificate and they can make good profit.
- Making owners aware of the high cost of retrofitting and the difficulties they will have to face to retrofit.
- Showing and convincing through facts and analysis to the clients so that they can get a clear idea of the extra cost that will deliver them a lot of benefits over time.
- Organizing workshops, seminars, drills, TV/radio/newspaper features, advertisements, etc for creating public awareness.
- The inclusion of the BNBC in all engineering and relevant disciplines at universities should be mandatory.

- Contractors and masons should not be paid until they follow the exact design approved by RAJUK.
- Penalties should be imposed on those who do not follow BNBC.
- Creating awareness and providing training to stakeholders from the community level to respond to the impacts of disasters.
- Meetings should be arranged monthly headed by chief engineers, project operations head, structural head, advisors of the company and other such leaders where training and instructions are provided to employees.
- Council or committees of masons should provide their masons the information about rules and regulations of constructing a building.
- RAJUK should be monitoring and strictly controlling implementation of building codes.
- All bodies related to construction need to be concerned about building codes for a safe, disaster-resilient building.
- Bank loan policy should be flexible with nominal interest rate for construction that follows the BNBC.
- The government can initiate a policy such as, "If a building is designed complying to building codes, approval time should be less for the building permit." (For regular building approval, it takes 2-3 months, but for BNBC-complaint it should be less than a month).
- Introducing people with the codes and penalties for denying codes.
- People should be warned of the disastrous consequences of neglecting the BNBC.
- Related institutions should work together for integrated planning.
- Providing occupancy certificates to encourage compliance.
- Providing soft home loans from House Building Finance Corporation if the BNBC is properly followed.
- Risk-sensitive land use planning has to be promoted for Dhaka and other cities in case of construction of buildings and other infrastructure.
- Owners should only be given home loans when they submit the structural design to RAJUK done by professional engineers following the BNBC.
- A manual should be produced in Bengali so that people can easily understand the main aspects of building codes.
- Workers should be given extra bonuses if they receive training.
- Owners both private and other must be brought under supervision.
- Safety management should be used in workplaces so that workers never neglect their duties; this should be monitored strictly.
- Buildings owners can be given incentives.
- Creating awareness so that people can understand that reducing the adverse effects of disasters is more important over the long term than saving money.

- Manuals should be published with detailed and simplified building codes.
- Providing credits and certificates which can be used later for getting other jobs.
- Fast clearance should be given to those who construct infrastructure following building codes.
- Arranging different training programs, workshops for engineers and seminars for building owners.
- Land and geologic characteristics should be taken under consideration for construction and proper urban planning.
- Land use planning and geo-engineering data can be used for zoning areas according to hazards and risks.
- Formulation of long-term land use planning is needed.
- The monitoring and implementing agency like RAJUK has to be transparent and accountable.

18. Future research opportunities

The successful implementation of building codes plays a vital role in making a city disaster-resilient. Cities like Dhaka and others in Bangladesh experience widespread violation of building codes. Hundreds and thousands of buildings that have already been constructed in Dhaka in a haphazard manner are at risk of collapse in earthquakes and other disasters. Therefore, the city should identify mechanisms through scientific investigations on how to effectively implement building code compliance. In this case, continuous assessment of opportunities and challenges should be carried out. Future research can include assessing different stakeholders' opinions at a large scale encompassing all the communities of the city so that they can freely share their ideas and experiences. In addition, taking examples from countries where building codes are successfully implemented, research activities to explore mechanisms to promote such application of codes need to be initiated.

19. Conclusion

Bangladesh, a small country, hosts a large population while the capital city, Dhaka, accommodates close to 20 million people. Due to the large population, the city has been growing in a very irregular form and has urbanised in a very haphazard manner. Building construction at present and in the past has not been given due attention particularly with regard to the existing building regulations and codes. Therefore, over 90% of buildings that have already been constructed in the city are highly vulnerable to earthquakes and other hazards. The city has experienced several large building collapses where many people have died. Given these situations, it is extremely important for the city, and the whole country, to identify effective mechanisms to promote the implementation of building codes. Those who deal with the BNBC (e.g. engineers) should be taught at the university level through incorporating it into the curriculum. In addition, those who work in building construction can be trained through various ways. By giving them incentives and rewards, implementation of the BNBC can be promoted.

Figure 20. Housing construction, Nepal

SECTION 3: Case study: Nepal

Earthquakes represent the major and most devastating hazard in Nepal and the building codes of Nepal play a role on supporting the construction of earthquake resistant-buildings. However, existing codes do not include much information or provisions for making building floods or landslides resistant, even though Nepal faces such disaster events.

The case study focuses on earthquakes given they are covered in the National Building Codes of Nepal. Other hazards such as floods, landslides and drought also affect Nepal, but are beyond the scope of this report. Nonetheless, such hazards have been covered in the 'Grey Building Handbook', included here as an appendix and as a stand-alone publication translated into Bengali and Nepali.

Figure 21. Map of Nepal, image courtesy of Mapcruizin.com

(http://www.mapcruzin.com/free-maps-nepal/nepal_sm_2008.gif)

20. Geography and population of Nepal

Nepal lies in the central part of the Himalayas (Figure 21). The country has been divided into seven provinces and presently has 293 urban municipalities. Until 2014, Nepal had only 58 municipalities; the increase in municipalities reflects the urban population growth. There are four types of municipalities in Nepal, metropolitan city, sub-metropolitan city, municipality and rural municipality. In March 2017, after a report by the Local Level Restructuring Commission, the country was divided into 4 metropolitan cities, 13 sub-metropolitan cities, 276 municipalities and 481 rural municipalities. Further, the number of metropolitan cities increased to 6 after the upgrading of two sub-metropolitan cities.

21. Impacts of disasters on buildings and people in Nepal

Nepal is one of the most vulnerable countries in the world in terms of natural hazards. It is in the top 20th position in the list of multi-hazard prone countries in the world (Gautam, 2017). Further, the country lies in an active seismic zone between the Indian and Eurasian plates (MoHA, 2015).

The country has regularly witnessed major earthquakes. The first recorded event dates back to 1255 AD where the ruling king Abhaya Malla was killed and one-third of the valley's inhabitants perished in the same disaster (Rana, 1935). The destructive earthquake after 1255 was followed by other such events in 1408, 1681, 1803, 1810, 1833, 1934, 1980, and 1988) and continues today (Earthquake Loss Estimate, 2014). Furthermore, the country witnessed smaller earthquakes in 1988, 2001, and 2011.

One of the last great earthquakes was in 1934, measuring over 8.0 on the Richter scale and resulted in the death of 8,519 people with 207,740 structures damaged (Rana, 1935). The 1988 Eastern Nepal earthquake killed 721 people and injured 6,553, and 20,000 buildings collapsed or were damaged including 948 schools. The recent Gorkha earthquakes of 15th April 2015 and 12th May 2015, affected 31 districts of Nepal, of which 14 districts were declared 'crisis-hit'. The 2015 Gorkha earthquakes claimed more than 8,790 lives with thousands affected. Furthermore, it has destroyed more than 500,000 houses and damaged another 250,000 (NPC, 2015). Many scientific research studies conducted following the Gorkha earthquakes speculate that another earthquake of this magnitude could be even more devastating (Grandin *et al.*, 2015).

The impacts from earthquake events are often devastating and casualties and damage related to the Kathmandu Valley can be found in Table 5.

Table 5. Casualties and Damage of past earthquakes in the Kathmandu Valley

Year	**Date**	**Earthquake Epicenter**	**Casualties**		**Buildings / Temples**	
			Death	Injuries	Collapsed	Damaged
1988	21 Aug.	Udayapur	721	6553	650	1814
1934	15 Jan.	Bihar/Nepal	8,519	-	12,397	43,342
1837	17 Jan.	-	-	-	-	-
1833	26 Aug.	-	43	30	18,000	-
1823	-	-	-	-	-	-
1810	May	-	Moderate casualties		Many buildings and temples collapsed	
1767	June	-	-	-	-	-
1681	-		-		Many buildings and temples collapsed	
1408	-	-	Heavy casualties		Many buildings and temples collapsed	
1260	-		Heavy, Widespread famine and epidemic		-	-
1255	7 June	-	1/3 of total population including King Abhaya Malla Killed		Many buildings and temples collapsed	

22. Building regulations in Nepal

The damage assessment of the earthquake of 1988 revealed that destruction of buildings was mainly due to poor construction and low level of awareness of code requirements and earthquake resistant technology among local communities. Consequently, the National Building Code (NBC) Development Project was formulated through the Department of Buildings assisted by UNDP (UNDP Project NEP/88/054). The 20-volume draft code with four levels of application were prepared in 1994. To enforce the NBC, the Building Act 1998 was promulgated, but unfortunately could not be enacted due to technical difficulties. The Department of Urban Development and Building Construction (DUDBC) further added three volumes to the code. The entire set consisting of 23 volumes was approved by the Government of Nepal (GoN) in 2003. The Code contains provisions pertaining to architectural, structural, mechanical and electrical requirements and the objective is to protect the public by accounting for the influence of the local conditions on construction.

The NBC was enforced through the Building Act 1998 (first amendment 2007) and Building Regulation 2008, and was approved by the government. Although it was applicable to the whole country and a legally binding document across all 130 municipalities, it was not mandatory for village development committees that existed before recent local level restructuring in Nepal. Only a few municipalities adopted the building code before the 2015 earthquakes. Lalitpur sub-metropolitan city was the first municipality in Nepal to implement the NBC in the Building Permit Process through a declaration on the Earthquake Safety Day celebration on 16 January 2003.

The National Building Code (NBC) presents regulations and guidelines for buildings to control and improve the seismic performance of buildings to meet an acceptable level of safety. The Code incorporates four different aspects of building types according to the complexity of design and construction (Table 6):

1. International state-of-the-art
2. Professionally engineered structures
3. Buildings of restricted size designed by simple rules of thumb
4. Remote and rural buildings where control is impractical.

International state-of-the-art buildings

These include buildings with complicated designs usually found in developed countries. The structures must comply with existing international state-of-the-art building codes. However, they must also meet Nepalese requirements with respect to minimum design load and configuration.

Professionally engineered structures

Buildings designed and constructed under the supervision of engineers, buildings with a plinth area more than 93 square metres, building having more than 3 storeys, buildings with a span more than 4.5 metres and buildings with irregular shapes fall into this category. It covers public buildings like hospitals, meeting halls, factories, multi-story buildings and larger residential buildings.

Mandatory rules of thumb

The mandatory rules of thumb can be used in the case of buildings that meet certain criteria related to height, number of storeys and floor area: may be used by the non-experienced builder and junior engineer to apply for a building permit and in the construction process.

The documents that cover the aspects of mandatory rules of thumb are:

- Mandatory Rules of Thumb Reinforced Buildings with Masonry Infill (NBC 201)
- Mandatory Rules of Thumb Reinforced Buildings without Masonry Infill (NBC 205)
- Mandatory Rules of Thumb Load Bearing Masonry (NBBC 202).

Guidelines for remote rural buildings

The guidelines focus on changes required to make buildings seismic-resistant, which are not subjected to modern quantitative analysis and rational design considerations. They include earthen buildings and low-strength buildings (unfired masonry, mud mortar, rubble, and dry stones). Documents included in this section are:

- Guidelines for Earthen Resistant Building Construction: Earthen Buildings (NBC 204)
- Guidelines for Earthen Resistant Building Construction: Low strength Masonry (NBC 203).

Table 6. Summary of NBC categories for design and construction of buildings

S. No.	Type of Building Code	Purpose
1	International State-of the-art. Applicable codes: NBC 000	Applicable to large building structures. The structures must comply with existing international state-of-the-art building codes
2	Professionally Engineered Buildings	Buildings designed and constructed under supervision of engineers, buildings with plinth area more than 93 square metres, building having more than 3 storeys, buildings with span more than 4.5 metres and buildings with irregular shapes
3	Mandatory Rules of Thumb. Applicable codes: NBC 201, NBC 202, NBC 205	Buildings of a plinth area less than 93 square metres, less than 3 storeys, building having a span less than 4.5 metres and regular buildings designed and constructed by technicians in areas where professional engineers are not available
4	Guidelines for Remote Rural Buildings (Low Strength Masonry/ Earthen Buildings)	Buildings constructed by local mason in remote area and not more than 2 storeys

23. Building construction practices in Nepal

Since 2015 the NBC has become mandatory for every municipality and is enforceable. The main municipalities and also the village municipalities are bound to follow the NBC for new construction which includes the massive reconstruction after the Gorkha earthquakes.

The enforcement of the building codes in all the municipalities is ensured through the building permit system. The building permit is provided for construction of a building only when the design and drawings of the building fulfils the NBC provisions and by-laws and the building completion certificate is provided to demonstrate that the building is constructed as per the design and drawings. Municipalities such as Dharan have also implemented a reward-and-punishment system where contractors who do not build according to NBC compliant design and drawings will lose their license to work in their municipality. Furthermore, upon demonstration of good work the municipality rewards contractors during different events such as the Earthquake Safety Day. The same municipality has also introduced supervision of construction work with an additional charge of NRs. 5 per square ft (0.93 square metres). They also provide incentives to owners (50% discount in fee) when they apply for a permit to retrofit their existing buildings.

24. Research approach and methodology

Nepal has 205 new municipalities that have recent experience with the implementation of building codes while of the remaining 58 municipalities a few have already implemented the NBC. The selection of the case study area includes both the old municipalities (having a long experience of the implementation of building codes) and new municipalities (which have only recently started the implementation). A total of five municipalities were selected as part of the case study areas. Municipalities in the Kathmandu Valley - where the capital of the country is situated - were selected in addition to a small number of municipalities external to the Valley. The three municipalities in Kathmandu Valley were Lalitpur (first municipality to implement NBC), Thimi municipality and Budhanilkhanta municipality (new municipalities) (See figure 8). Two municipalities outside Kathmandu Valley were Dharan (implementation in 2007) and Duhabi (new municipality).

bb. Data Collection

The key stakeholders selected for the interviews were engineers and government officials working in the field of building code implementation and building construction, and politicians who play an important role in urban development and housing. A total of ten engineering professionals, one engineering academic and three politicians/administrators were interviewed.

cc. Details of interview participants

A total of 14 key stakeholders participated in semi-structured interviews. All the respondents are either directly or indirectly related to the NBC enforcement. Among the respondent 57% were from the age group of 31-50, 21.5% from 18-30 and 51-70 age group (Figure 22).

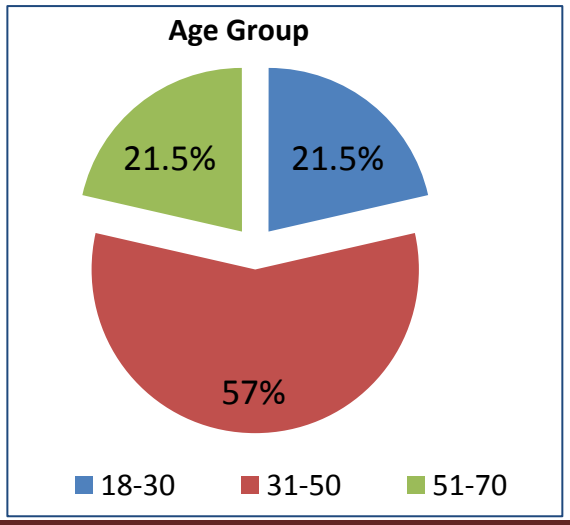


Figure 22. Age group of interviewees

In terms of employment experience in the construction industry, 50% of the respondents had been working in the construction industry for more than 10 years. Those who had worked in the construction industry for 2-5 years were as equally represented as respondents who had worked in the industry for 6-10 years; both were 21.5% of the overall group, and the remaining 7% had less than 2 years' experience (Figure 23). Of all of the respondents, 79% were engineers. (Figure 24). Most of the engineers interviewed, particularly in local government were involved in checking designs and building drawings for compliance to building codes and building by-laws, and providing approval for construction. In terms of length of experience in their current position, 21% had been there for less than 2 years, around half of the respondents had 2-5 years of working experience in the current position and 29% had been there for more than 5 years (Figure 25).

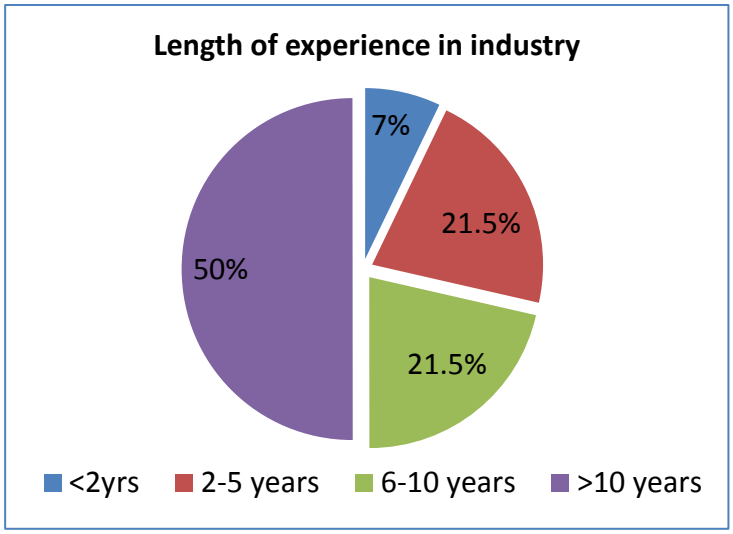


Figure 23. Years of experience in the construction industry

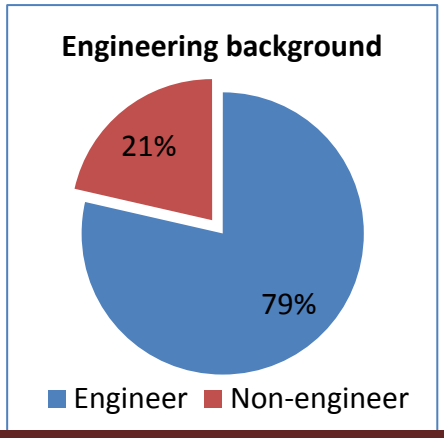


Figure 24. Engineering background of interviewees

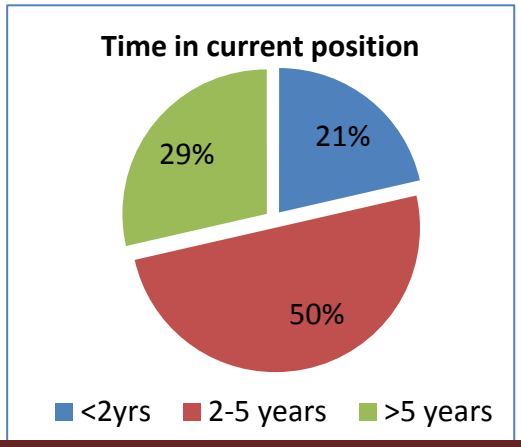


Figure 25. Years spent working in current position

As for who the respondents were employed by, around 72% worked for local government, while 21% worked for the state and 7% for NGOs and private entities. Of these organisations, 29% worked in organisations with 50-100 staff, half (50%) of the respondents worked in an organisation with 101-500 staff, while 21% worked in an organisation with more than 500 people (Figure 26).

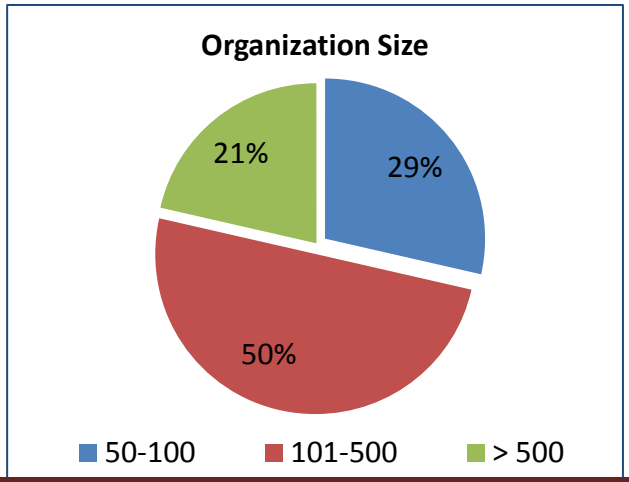


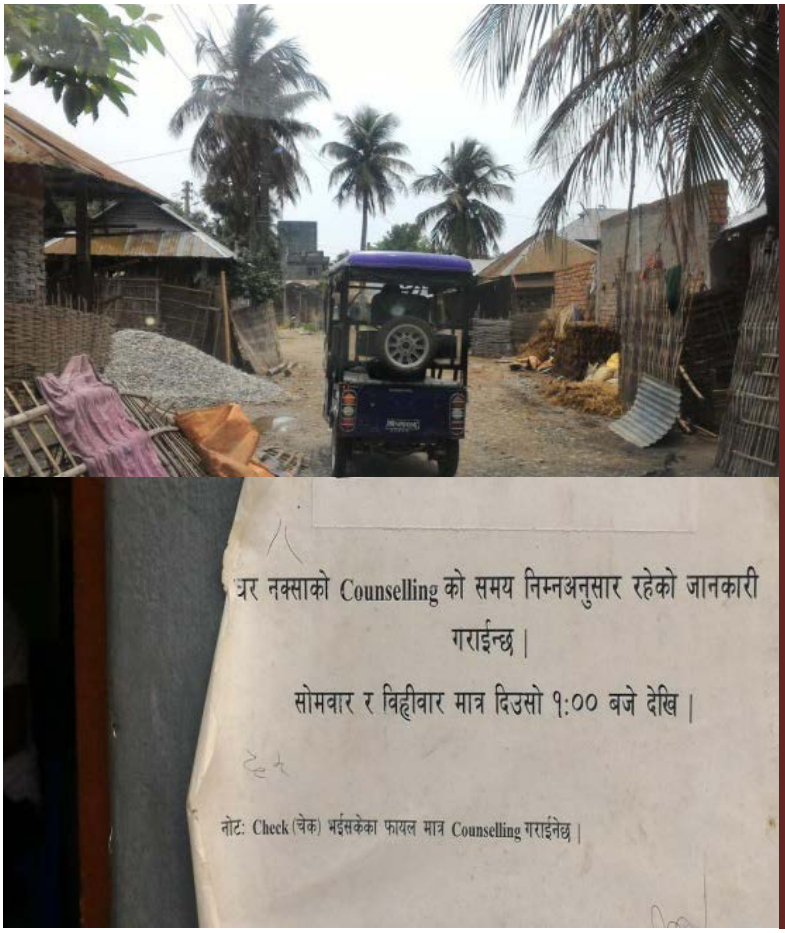
Figure 26. Distribution of co-workers

25. Results

dd. Participants' perception on building compliance

Almost all the organisations that the respondents worked in observed the Earthquake Safety Day to raise awareness on the building codes. They also provided different levels of training such as mason training: many municipalities consider this form of training as one of their successful strategies to promote voluntary compliance. Some organisations also used megaphones and media channels for dissemination of information regarding NBC. The Dharan and Thimi municipalities have conducted house owner counselling every week for those who are interested in applying for a building permit (Figure 27). The state organisation has also developed a number of guidelines, construction specifications, pamphlets, and prototype designs. They provide training on safe building construction to different levels of technicians such as engineers, sub-engineers, assistant sub-engineers and masons.

For many key stakeholders, traditional settlements are common in their working areas and they noted difficulty in the implementation of building codes across these localities. On one hand, traditional construction technology has stood the test of time, however, on the other it has not been incorporated properly into the NBC. The NBC has focused and provided details more on new or modern technology, such as reinforced concrete. Furthermore, the highly dense traditional settlements have certain construction details and characters which the NBC has not been able to capture in detail.



Fiure 27. Raising awareness in municipalities

(Above) Disseminating information by megaphones in Duhabi municipality on building permits

(Below) Notice of day and time of counselling for house owners in Dharan Municipality

ee. Reasons suggested by stakeholders for non-compliance of building codes

The key stakeholders pointed out a number of challenges in the compliance of the NBC, although all the respondents felt that the compliance has been more voluntary after the Gorkha earthquakes 2015.

Non-compliance of owners

- One of the biggest challenges is the lack of awareness of the owners regarding safety, the NBC and its compliance.
- Inner city areas where the land size is small and it has its own traditional technology and people with a weak economic background, the implementation of NBC is a challenge (Figure 28).
- Construction not undertaken under the supervision of skilled technicians due to economic constraints.

Figure 28.

Buildings in inner city areas, Nepal

Lack of experience of engineers

- Technicians do not have sufficient knowledge of designing especially in city centres where buildings such as high-rises are being constructed.
- Fresh graduates are unaware of the NBC.
- Awareness of the importance of NBC and its role in disaster resilience.
- Field implementation, especially of construction detailing such as lapping, stirrups, ties and other methods is problematic.

Government

- Inadequate institutional capacity (lack of skilled technical human resources).
- Lack of effective reward-and-punishment system.
- Political pressure to provide building permits or completion certificates, although the design and construction of a building lacks compliance to building codes.
- Gaps in the building permit system as the monitoring of the foundation is missing during the process of construction. Monitoring on the site is done below the damp-proof course (DPC) level where there is empty land and after above DPC.
- Strong political will to enforce building codes.

Issues with building codes

- The NBC has the limitation that it does not have clear instructions on steel structures.
- The MRT 205—which has been followed in several municipalities—has certain issues in that it does not consider practical aspects such as two ways eccentric, one-way eccentric, strap beam, combine foundation, and raft foundations.
- Ambiguity of MRT.
- Design of foundation when land is open from only two sides.

Other problems identified

- Quality of materials.
- Large stocks of old buildings exist, which were not built according to building codes and retrofitting them is challenging.
- Most of the respondents pointed out that awareness of all the stakeholders is the basic and key aspect to help encourage voluntary compliance. In Nepal, where most houses are owner-driven, it would be fruitful to develop incentive mechanisms for the house owners to encourage NBC compliance.
- Proper system in the municipality with less a less bureaucratic process.
- Political will to make the city safe.

26. Key findings and recommendations

The study has revealed a number of challenges and also recommended areas of improvement. It has outlined some major impediments to the compliance of NBC:

- Capacity development
- Awareness of different stakeholders
- Involvement of academia
- Need to find solutions on retrofitting of existing buildings
- Incentives.

27. Future research opportunities

The results obtained from the study point out that further studies can be conducted to find ways to formalise and standardise the construction of traditional technology (informal settlements). Research can also be conducted on different ways and means of raising awareness of different stakeholders, including politicians.

Figure 29. A building damaged by the 2015 Gorkha earthquakes in Nepal

3. Conclusions

28. Responses to research questions

The discussion of the results of the research is structured along the main research question and sub-questions (see 1.2.b). To begin with, the sub-questions are addressed, which then leads to an analysis of the findings pertaining to the main research question. The discussion is drawn from the preceding case studies and literature reviews.

ff. Responses to the sub-questions

Sub-question 1:

What are the strengths and weaknesses in terms of disaster resilience of building codes globally, and specifically in the project countries?

Some of the key issues below were revealed broadly in the global literature review, which were then further revealed in more detail in the case study contexts, discussed below under Sub-question 2.

- **Building regulations vs Building codes**: One of the key weaknesses is the lack of distinction between building regulations and building codes. Building codes and regulations are often used simultaneously, but their scope and meaning varies. 'Building regulations' usually refers to land use planning, setbacks and easements, building character, density, height, etc, which can be at the urban or settlement level. On the other hand, 'building codes' are specific to the design and construction of individual buildings, with technical building provisions or construction requirements to maintain certain standards of safety, human comfort and well-being.
- **Integration between Building regulations vs Building codes:** The other weakness is that the level of differentiation and integration between regulations and codes varies widely, both in developed and developing countries, making compliance and enforcement complex for achieving disaster resilience. For example, even if a building is built to high safety standards following codes, if it is allowed to be built in a vulnerable location, it may not be resilient to the impacts of disasters. Japan is one example where they are strongly integrated, which has been advantageous in minimising the impacts of disasters.
- **Mounting emphasis to act**: In many developing countries, building codes do exist but are often not mandatory. However, one of the strengths is that after the 2015 earthquakes in Nepal, there is stronger emphasis on implementation of the National Building Code. Another strength is in Bangladesh, at least in the new and formal urban developments, where there is an attempt to enforce building regulations; there are also claims by some builders that the National Building Code is followed.
- **Need for greater intervention**: Despite the mounting emphasis many challenges exist in terms of capacity, compliance and enforcement; there is very little in the way of building regulations in Nepal. There is a similar situation in Bangladesh, where typically, at the national level and even at the wider urban level, both the building regulations and codes are disregarded, and in many cases, there is little knowledge of them even among built environment professionals.

Figure 30. Informal sector buildings range from slum dwellings to brick-and-concrete buildings, as seen from these photos from Bangladesh (above) and Nepal (below)

Sub-question 2:

What knowledge and insights can be gained from institutional and community stakeholders in the project countries on opportunities and challenges for facilitating compliance to safe building codes?

In the two project countries a wide range of stakeholders were interviewed, including from the public and private sectors, academia, built environment professionals and construction workers. The insights gained from these interviews are discussed earlier in the case studies, and the key challenges can be summarised along the following key lines:

- **Large Informal sector:** The widespread and proliferating informal sector in both project countries where building codes and regulations are not followed (Figure 30). In Nepal, there is an attempt to contextualise building codes for small buildings and those built out of traditional materials (e.g. earth, low-strength masonry), but there is no such effort in Bangladesh, where the building codes pertain to buildings constructed out of formal sector materials such as concrete and brick; thus, there is little relevance of the codes for the informal sector. In addition, there is a large existing building stock, mostly built informally and some of the buildings quite old and deteriorating, and the inhabitants there are particularly at risk (Figure 31). There is hardly any exploration on how this risk might be addressed. The formation and existence of the informal sector is fuelled by the challenges discussed below.
- **Lack of awareness and knowledge:** This was a key challenge in promoting compliance to building codes. Although building codes exist in both the countries, there was widespread lack of awareness about it and knowledge on how to understand and apply it, spanning from built environment professionals to construction workers. Codes are often understood as bringing resilience only to earthquakes, not the wide range of hazards in these countries; indeed, particularly in Nepal, the building codes deal primarily with earthquakes and not interpreted for other hazards. Such awareness and knowledge comprise a prerequisite to compliance; without knowing the codes or fully understanding them, one cannot be expected to comply to them.
- **Lack of capacity:** This is related to the above issue – knowledge is an essential basis for building capacity in interpreting, implementing and complying with building codes. Once again, this capacity building need is at all stakeholder levels from formally trained built environment professionals to informal sector construction workers.
- **Perception of extra cost:** Incorporation of building codes does incur an extra expense, but this is not significant if their long-term safety and disaster resilience benefits are considered. In the project countries, building codes are widely perceived as costly and hence avoided, without any serious cost-benefit analysis presented by professionals or demanded by building owners.
- **Corruption:** This is a key challenge in promoting compliance to building codes and building regulations. In Bangladesh where building regulations (or bye-laws) are somewhat enforced in the more affluent and formal sector buildings, there are reports of violation in the wider context; building codes are by and large ignored, if known at all. In Nepal, even when there is an institutional drive to implement building codes, there is a tendency to avoid them wherever possible. Political patronage and bribery are some of the key corruption instruments.

Although at this time the challenges outweigh the opportunities, the opportunities below were drawn from the interviews:

- **Institutional initiatives:** Recent disasters in the two countries, namely the Rana Plaza garment factory collapse in Bangladesh and the 2015 earthquakes in Nepal brought institutional focus on the importance of building codes. In Bangladesh, the key urban regulatory body, RAJUK, has embarked on a building resilience program supported by the World Bank. Similarly, in Nepal, there is strong international support to promote building codes and the government has mandated the implementation of building codes, which provides an opportunity for promoting compliance.
- **Educational initiatives:** Although not yet at the level as required, there are some initiatives to include education on building codes at the tertiary level. In Bangladesh, only in the curricula of the premier engineering university, BUET, building codes has been included, but perhaps it is the beginning for more widespread uptake. In Nepal, the Institute of Engineering in the premier educational institution, Tribhuvan University, is spearheading education on building codes, and again, can be a basis for replication by other educational institutions.
- **Awareness and capacity building*:*** Although Bangladesh is lagging behind current international approaches, there are quite a few initiatives in Nepal to build awareness and capacity - the 'Earthquake Safety Day' is celebrated in a significant manner and serves as a vehicle for raising awareness on safe construction practices. Training of masons in safe construction is beginning to be done widely in Nepal, a way of building capacity at that level which has relevance for the informal sector. There is the opportunity for Bangladesh to learn from these initiatives.

Figure 31. Old and deteriorating buildings in Kathmandu, Nepal; note how the buildings are buttressed to prevent toppling

Sub-question 3:

What practice-and-policy guidelines are required to facilitate voluntary compliance and implementation of safe building codes?

Practice-and-policy guidelines relevant to the two project countries were discussed earlier in the case studies. Here some of the key elements, relating to the challenges and opportunities discussed above under Sub-question 3, are drawn out.

- **Increasing Awareness:** Strong and widespread initiatives on building awareness at all levels is required. Although some initiatives in this regard have been identified above, there is scope for a much more concerted and extensive effort. Policies for doing so can be implemented in partnership between public, private and civil society actors, and can be upscaled for the wider community level.
- **Professional bodies reinforcing codes in education:** Policies should be targeted for capacity building on building codes at all levels ranging from incorporation of knowledge on building codes in tertiary level education of built environment professionals to training of construction workers. The "Grey Building Handbook" produced in this project is an initiative in this direction and can serve as a training manual for informal sector builders.
- **Financial incentivisation for compliance:** A range of policy instruments, indicated particularly in the Bangladesh case study context, and to some extent in the Nepal case study, including financial incentives, 'reward-and-punishment', and regulatory code of professional practice could move forward the building codes compliance agenda. Coupled with awareness on the importance of building codes for disaster resilience, it could be the basis for more widespread voluntary compliance.
- **Formation of new authorities/institutions:** From the investigations in Bangladesh, it was found that the need for a specific authority for implementation and enforcement of building codes was expressed. RAJUK in Bangladesh is primarily involved in approving building permits and monitoring of construction relating to building regulations and there is no agency for building codes implementation. However, RAJUK with the support of the World Bank has embarked on a new program for implementation of building codes, and perhaps this is an opportunity for integration of regulations and codes under one authority.
- **More integrated and targeted guides:** In Nepal on the other hand, the Ministry of Urban Development oversees implementation of building codes, primarily relating to earthquake resilience, and there is limited focus on building regulations. There is thus scope here for integration of codes and regulations, as well as building codes dealing with a wider range of hazards.

29. Responses to the main research question:

How can compliance to voluntary safe building codes be facilitated in the current contexts of Bangladesh and Nepal for increased disaster resilience?

The discussions around the research sub-questions provide pointers to addressing the main research question. In order to do that, it would be useful to broadly categorise buildings into two sectors, formal (a relatively small proportion in the national contexts of the two project countries, and indeed throughout South Asia, but because of the large population, and growing prosperity and aspirations, significant in absolute terms) and informal (the majority of buildings in the two countries, ranging from rudimentary slum dwellings to brick-and-concrete multi-storey buildings). Various approaches were suggested in the interviews and literature to catalyse voluntary compliance such as incentives, tax benefits, reduced insurance premiums and reverse mortgage, inclusion in educational curricula and school buildings, contextualised approach according to country, sector-wide training including construction workers and informal builders, and perhaps most importantly, raising awareness. A mixture of such strategies in varying extents in the formal and informal sectors as discussed below can be way forward in addressing the above research question.

gg. Formal sector

In the major cities in Bangladesh and municipalities in Nepal, there are already initiatives for implementing building codes and regulations in the formal sector, although as yet there is a gap in the coverage and also reports of violation and corruption. The suggestions discussed above relating to capacity building, financial incentives, education and enforcement (fines, rewards, monitoring of practitioner licensing, etc) pertain to the formal sector as mechanisms for promoting voluntary compliance, and there are already some small beginnings of voluntary implementation of codes in some municipalities in Nepal and by some real estate developers in Bangladesh. These examples can be a basis for upscaling voluntary compliance initiatives.

hh. Informal sector

Raising awareness is the main pathway to achieving voluntary compliance in the informal sector. The key issue is that many of the building codes in developing countries have been adapted from developed countries, but having significantly lower resources and weaker governance, the codes prove difficult to implement in the socio-economic conditions of the developing world. A large part of the population in the project countries live in informal settlements and rural areas, and the high building standards specified in the codes are simply not feasible.

Building codes specify a wide range of design and construction guidelines and standards to enable safety, health and comfort for users and occupants of buildings, where the safety aspects are the most crucial to protecting human lives and well-being from disaster impacts. Therefore, in the developing world context where lack of resources and other factors are barriers to implementing a comprehensive array of building codes, to begin with this most basic and critical life-saving element makes sense and signifies building standards that specifically address disaster resilience. Thus a ‘Grey Building Handbook’ (see appendix) derived from the research and contextualised for Bangladesh and Nepal

comprises one of the main outputs of this project, where a suite of safe building options is presented to match different incomes and site conditions.

The approaches in Nepal, such as specific codes for traditional and small buildings and training of masons, address the safety needs of the large informal sector. While there is scope for upscaling these approaches in Nepal, there is also opportunity for Bangladesh to gain lessons, and contextualise and implement such approaches.

30. Conclusions

The overarching goal of this project was to undertake research on approaches and options for promoting voluntary compliance to safe building codes for disaster resilience, focusing on two case study contexts – Bangladesh and Nepal. A secondary, though equally important, goal was to develop a handbook that would enable practitioners, local builders and construction workers in low-income communities to begin the process of building disaster resilient buildings, which would eventually help them to move towards compliance to a wider gamut of building codes. Although these goals were focused on the two project countries, their outcomes have relevance for the wider region and other developing countries with similar conditions and hazard vulnerability.

The project has revealed valuable lessons on the resonance of the findings of the literature review and empirical investigations. The similarity of findings in the two project countries indicate the nature of the problem being essentially related to issues of governance, institutional and technical capacity, and public awareness. Nonetheless, despite the similarities, there were lessons unique to each country, providing an opportunity for sharing of lessons through collaborative research and the considerable benefits that can arise from knowledge sharing and the cross-fertilisation of expertise and ideas.

Experience from the project has shown that the engagement of a wide range of project stakeholders in both countries has helped raise awareness of the building codes issue. Compliance to building codes is a complex issue, yet the signs uncovered of growing awareness and initiatives indicate that disaster resilience through widespread voluntary compliance of safe building codes and regulations is a possibility that might be realised over time in the future.

4. Future Directions

This project pointed to further research directions to broaden the understanding of the multi-faceted topic of building codes compliance, which includes:

- Developing options for retrofitting or strengthening old buildings, following to the extent possible the construction standards as prescribed in the building codes of the respective project countries.
- Stakeholder and policy mapping for better understanding of possible roles in the integration of building codes and building regulations.
- Exploration of community perceptions of risk and willingness for voluntary compliance, and the incentives and policy environment required for it.

- Developing methods of raising public awareness and the channels and stakeholders that might be effectively involved for that purpose.
- Understanding the role of social media in how it might be utilised to promote widespread compliance to building codes and regulations.
- Investigation of the role of the private sector, and how effective partnerships can be forged between the public and private sectors, and civil society.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6. Appendices

i. List of early career researchers.

ii. Introductory workshop agenda.

iii. Interim workshop agenda.

iv. Final workshop agenda.

v. CIFAL website report on project workshop.

vi. Journal paper based on the project.

vii. Presentation at the International Conference on Building Resilience, Bangkok, 2017.

viii. Grey Building Handbook: English.

ix. Grey Building Handbook: Bengali.

x. Grey Building Handbook: Nepali.

Appendix i: List of early career researchers involved in the project.

Name	*Institution*	*Key Role*
Dr Josephine Vaughan, Casual Academic	UoN	Research Assistant; final report production support
Ms Georgia Kissa, PhD Scholar	UoN	Research Assistant; 'Grey' Building Handbook production support
Ms Oluwadunsin Ajulo, Scholar	UoN	Research Assistant; global literature review support
Mr Shaiful Islam Bhuiyan, Engineer	DU	Research Assistant; data collection and country report production support
Ms Inu Pradhan-Salike	TU	Research Assistant; data collection and country report production support

Appendix ii: Introductory workshop agenda





INTRODUCTORY WORKSHOP

Kathmandu, Nepal, 8-10 November 2017

"Understanding the opportunities and challenges of compliance to safe building codes for disaster resilience in South Asia - the cases of Bangladesh and Nepal."

A research project funded by the Asia Pacific Network for Global Change Research (APN)

Project partners: University of Newcastle, Australia; Dhaka University/BRAC University, Bangladesh; Tribhuvan University, Nepal.

AGENDA

Day 1: 08/11/17		
08:30 – 9:00	Registration	
09:00 – 09:15	Welcome speech	Dr Hari Darshan Shrestha
09:15 – 09:30	Introductions/ Scope of workshop	Dr Ifte Ahmed
09:30 – 10:00	Project Overview	Dr Ifte Ahmed
10:00 – 10:30	Introduction to the Disaster & Development Research Group, University of Newcastle	Dr Jason von Meding
10:30 – 10:45	Break	
10:45 – 11:15	Introduction to the Disaster Research Training & Management Center (DRTMC), Dhaka University and Postgraduate Programs in Disaster Management, BRAC University	Prof Humayun Kabir
11:15 – 11:30	Introduction to the Centre for Disaster Studies, Tribhuvan University	Mr Nagendra Sitaula Shrestha
11:30– 12:15	State of building codes for disaster resilience in Nepal	Dr Ramesh Singh. DG DUDBC Mr Man Thapa, DRR expert Dr Gokarna Motra, Campus chief, IOE
12:15 – 12:30	General discussion; planning for the next days	Dr Ifte Ahmed/ Dr Hari Darshan Shrestha
12:30 – 13:30	Lunch	
Day 2: 09/11/17		
08:30 – 9:00	Scope of Day 2	Dr Ifte Ahmed
Country groups present key literature and initiatives on building codes in respective countries		
09:00 – 09:30	Australia	
09:30 – 10:00	Bangladesh	
10:00 – 10:30	Nepal	
10:30 – 10:45	Break	
10:45 – 11:00	Introduction to scope of empirical investigation	Dr Ifte Ahmed
Country groups present key stakeholders for interviews and/or project plan		
11:00 – 11:30	Australia	
11:30 – 12:00	Bangladesh	
12:00 – 12:30	Nepal	
12:30 – 13:30	Lunch	
Day 3: 10/11/17		
09:00 – 12:30	Field visit to reconstruction sites	

Appendix iii: Interim workshop agenda

INTERIM WORKSHOP

Hotel Lake Breeze, House 15, Road 42, Gulshan 2, Dhaka 1212, Bangladesh, 23-25 April 2018

"Understanding the opportunities and challenges of compliance to safe building codes for disaster resilience in South Asia - the cases of Bangladesh and Nepal"

A research project supported by the Asia Pacific Network for Global Change Research (APN)
Project partners: University of Newcastle, Australia; Dhaka University/BRAC University, Bangladesh; Tribhuvan University, Nepal.

AGENDA

Day 1: 23/04/18 – Public Event		
08:30 – 9:00	Registration	
09:00 – 09:10	Welcome speech	Prof Humayun Kabir
09:10 – 09:20	Introductions/ Scope of workshop/Project Overview	Dr Iftekhar Ahmed
09:20 – 9:30	Introduction to the Disaster & Development Research Group, University of Newcastle	Dr Iftekhar Ahmed
9:30 – 10:00	Key results of a Global Literature Review on Building Codes and Disaster Resilience	A/Prof Thayaparan Gajendran
10:00 – 10:15	Break	
10:15 – 10:30	Introduction to the Centre for Disaster Studies, Tribhuvan University	Dr Hari Darshan Shrestha
10:30 – 11:00	Key results of Field Investigations on Building Codes and Disaster Resilience in Nepal	Dr Hari Darshan Shrestha and Ms Inu Pradhan-Salike
11:00 – 11:15	Introduction to Disaster Research Training & Management Center, Dhaka University and Postgraduate Programs in Disaster Management, BRAC University	Prof Humayun Kabir and Dr Mohammed Faruk
11:15 – 11:45	Key results of Field Investigations on Building Codes and Disaster Resilience in Bangladesh	Prof Humayun Kabir and Mr Shaiful Islam Bhuiyan
11:45 - 12:15	Keynote: State of building codes for disaster resilience in Bangladesh	Engr Abdul Latif Helaly
12:15 – 12:30	Fire Accidents, Building Collapse and Rescue Operations in Bangladesh	Major A K M Shakil Newaz
12:30 – 12:45	Open discussion	Moderated by Dr Iftekhar Ahmed and Prof Humayun Kabir
12:45 – 13:00	Acknowledgements/ Note of thanks	Prof Humayun Kabir
13:00 – 14:00	Lunch	

Day 2: 24/04/18 – Internal Workshop		
9:00 – 9:30	Scope of Day 2	Dr Iftekhar Ahmed
Country groups present plans for next stages of the project		
09:30 – 10:00	Nepal	
10:00 – 10:30	Bangladesh	
10:30 – 10:45	Break	
10:45 – 11:15	Australia	
11:15 – 12:30	Workshop on project issues: financial, reporting, publications, long-term plans, etc.	
12:30 – 13:30	Lunch	

Day 3: 25/04/18	
09:00 – 12:30	Field visit (Rana Plaza, Savar Adjacent Areas)

Appendix iv: Final workshop agenda

FINAL WORKSHOP

Main Hall, Institute of Engineering, Tribhuvan University, Pulchowk Campus, Lalaitpur, Nepal
28-30 August 2018

"Understanding the opportunities and challenges of compliance to safe building codes for disaster resilience in South Asia - the cases of Bangladesh and Nepal"

A research project supported by the Asia Pacific Network for Global Change Research (APN)
Project partners: University of Newcastle, Australia; Dhaka University/BRAC University, Bangladesh; Tribhuvan University, Nepal.

AGENDA

Day 1: 28/08/18 – Public Event		
08:30 – 9:00	Registration	
09:00 – 09:15	Welcome speech	A/Prof Hari Darshan Shrestha
09:15 – 09:30	Introductions/ Scope of workshop/Project Overview	Dr Iftekhar Ahmed
09:30 – 10:00	Key aspects of the project's outcomes	Dr Iftekhar Ahmed
10:00 – 10:15	Break	
10:15 – 10:45	Key aspects of the "Grey Building Handbook" (including introductions to translated versions)	Ms Georgia Kissa
10:45 – 11:15	Key highlights of Field Investigations on Building Codes and Disaster Resilience in Bangladesh	Prof Humayun Kabir, Dr Mohammed Faruk and Mr Shaiful Islam Bhuiyan
11:15 – 11:45	Key highlights of Field Investigations on Building Codes and Disaster Resilience in Nepal	Dr Hari Darshan Shrestha, Mr Nagendra Situala and Ms Inu Pradhan-Salike
11:45 - 12:15	Keynote: State of building codes for disaster resilience in Nepal	Mr Dwarika Shrestha, Under Secretary, Ministry of Urban Development
12:15 – 12:45	Open discussion	Moderated by Dr Iftekhar Ahmed and A/Prof Hari Darshan Shrestha
12:45 – 12:50	Acknowledgements/ Note of thanks	A/Prof Hari Darshan Shrestha
12:50 – 13:00	Closing	Vice Chancellor, Tribhuvan University/Dean, Institute of Engineering
13:00 – 14:00	Lunch	
Day 2: 29/08/18 – Internal Workshop		
9:00 – 9:30	Scope of Day 2	Dr Iftekhar Ahmed
Country groups present plans for next stages of the project		
09:30 – 10:00	Nepal	
10:00 – 10:30	Bangladesh	
10:30 – 10:45	Break	
10:45 – 11:15	Australia	
11:15 – 12:30	Workshop on project issues: financial, reporting, publications, long-term plans, etc.	
12:30 – 13:30	Lunch	
Day 3: 30/08/18		
09:00 – 12:30	Field visit (Municipality in Kathmandu Valley, TBA)	

Appendix vi: CIFAL website report on project workshop

http://www.unitar.org/cifal-newcastle-organizes-workshop-building-codes-disaster-resilience Accessed 21.08.2018.

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CIFAL Newcastle Organizes Workshop on Building Codes for Disaster Resilience

23 April 2018, Dhaka, Bangladesh – UNITAR's Affiliated Center for Authorities and Leaders (CIFAL) in Newcastle, Australia, organized an interim workshop as part of the project 'Understanding the Opportunities and Challenges to Safe Building Codes for Disaster Resilience in South Asia – the cases of Bangladesh and Nepal' in Dhaka, Bangladesh. Around 20 participants from Bangladesh and Nepal took part in the workshop.

The workshop is part of a series which includes the project team members from Australia, Bangladesh and Nepal, as well as relevant participants working in the building codes and disaster resilience field. This project sees a team of University of Newcastle researchers exploring the opportunities and challenges of compliance to safe building codes in assuring resilience in the face of disasters. The team, from the School of Architecture and Built Environment, has been successful in winning a competitive research grant from the Japan-based Asia Pacific Network for Global Change Research (APN) to explore the opportunities and challenges of compliance to safe building codes for disaster resilience in South Asia.

They have partnered with researchers in Dhaka University and BRAC University, Bangladesh and Tribhuvan University, Nepal, to undertake this collaborative research project that spans across the Asia-Pacific region. Looking at specific cases in Bangladesh and Nepal, the team, led by Dr. Ifte Ahmed is exploring the role that safe building codes play in assuring resilience in the face of the frequent disasters that affect these countries and to understand how these codes might be more widely adopted to reduce disaster risks. The second day of this trip involved planning for the subsequent stages of the project, and on the third day a field visit outside Dhaka was undertaken, particularly to the site of the Rana Plaza factory building collapse. Planning for the final workshop, which will be held in August 2018 is underway.

Photo: Participants during the workshop

vi. Journal paper based on the project.

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7th International Conference on Building Resilience; Using scientific knowledge to inform policy and practice in disaster risk reduction, ICBR2017, 27 – 29 November 2017, Bangkok, Thailand

Compliance to building codes for disaster resilience: Bangladesh and Nepal

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Abstract

This paper reports on a project that explores the opportunities and challenges for compliance with safe building codes for disaster resilience, focusing on two countries - Bangladesh and Nepal. Recent disasters in both countries highlight a significant problem of non-compliance with building codes. However, these disasters have brought institutional and community awareness of the importance of safe building codes, presenting a germane opportunity to explore the issues associated with compliance. Building codes do exist in the two countries, but due to socio-economic, political and cultural conditions compliance is generally lacking or limited, particularly in the large informal building sector. There is thus a need for understanding how these codes might be more widely adopted to enable disaster resilience. Collaboration between partner universities in these countries with experience in this field address: sharing the understanding that evidence-based knowledge is a critical component in the commitment to local action; improving institutional and community awareness of the importance of compliance with/barriers to enforcement of codes; fostering communities of collaborative practice; and developing local and international dissemination networks. A log-frame approach indicates the rationale, assumptions and expected outcomes of the project. The project is at a preliminary stage and this paper discusses the framework associated with the exploration of barriers and enablers to building codes compliance.

Peer-review under responsibility of the scientific committee of the 7th International Conference on Building Resilience.

Keywords: Building codes; Bangladesh; Nepal; Disaster resilience; Compliance.

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1. Introduction

This paper reports on a project that explores the opportunities and challenges to compliance with safe building codes for disaster resilience, focusing on two countries in South Asia – Bangladesh and Nepal. The generation of scientific knowledge on building codes and construction continues apace globally, but its application to disaster risk reduction and resilience-building is lacking. South Asia is a case in point because land-use and building code frameworks are generally inadequate in low-income countries, such as the case study countries in this project. The bulk of buildings are constructed informally; rough estimates indicate that over 80% of housing in these two countries is informal [1][2]. There is very little or no application of building codes in informal sector construction. Even in the very small proportion of formal sector housing, adherence to building codes are generally lacking or limited at best. Building codes are not well-integrated into construction and planning regulations. Bangladesh and Nepal have building codes [3][4], but enforcement and compliance face significant challenges; the codes serve mainly as good practice guidelines. It is up to professionals, builders or authorities to follow them. Recognising the significance of this issue, the authors developed a research project to examine this situation, which was awarded a research grant from the Asia Pacific Network (APN) for Global Change Research. The project has recently been initiated, so this conference presents an opportunity to seek feedback on the project's research framework.

2. Knowledge relating to safe building codes

The world is continually being barraged by disasters; in the recent decade there were more than 6,300 recorded disasters, of which close to half occurred in Asia [5], a continent with a large number of developing countries where disaster impacts are the most severe. Globally, governments, international development agencies and many organisations are taking disasters and the need for resilience seriously, reflected in the approval by the United Nations member countries of the Sendai Framework for Disaster Risk Reduction (SFDRR) [6]. The SFDRR, within its wider global resilience agenda, clearly articulates the importance of safe building codes: "To encourage the revision of existing or the development of new building codes and standards" [6] is a priority in the framework. Another recent international commitment through the United Nations, the Sustainable Development Goals (SDGs) [7], has targets that recognise the importance of disaster risk reduction [8]. One of these targets is to "Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials" – and building codes would definitely be a vehicle for achieving this target. In the global 'Resilient Cities Campaign' of the United Nations Office of Disaster Risk Reduction (UNISDR), a key element is to "Apply and enforce realistic, risk compliant building regulations and land-use planning principles" [9]. Prominent international development agencies such as the World Bank, United States Agency for International Development (USAID) and Japan International Cooperation Agency (JICA) have begun to address this global priority for resilient buildings and are promoting the uptake, compliance and implementation of safe building codes [10][11][12].

Building codes have been defined widely, but for the sake of this research project the definition by a notable dictionary - "A collection of regulations adopted by a city to govern the construction of buildings" [13] – helps illustrate a key point. Clearly this definition, and by extension this approach to building codes, relates to developed countries where building codes and building regulations are integrated into the legislative environment whereby enforcement provisions mandate compliance (see for example, the Australian National Construction Code in [19]). The broader term 'building regulations' as in developed countries includes both land-use planning and building codes [14]. This integration enables minimising the impacts of disasters, as evident from Japan, which has "… some of the world's most stringent building codes" [15], but it is also pointed out that that it took more than seven decades, and a series of disasters, for Japan to arrive at this stage [16]. However, this is obviously not the case in many developing countries where building codes are often not mandatory (see for example, [17]); for example, in an earlier version of the Bangladesh National Building Code (BNBC), it is stated that, "… the Building Code is not an independent legislation or act, rather it is a national level approved document …" [18]. It is widely reported that enforcement and compliance of building codes face serious barriers related to governance and resource constraints, among other such factors [17][19][20][21][22][23], resulting in vulnerability to disasters.

A key issue is that many of the building codes in developing countries have been adapted from developed countries [12], but having significantly lower resources and weaker governance, the codes prove difficult to implement in the

socio-economic conditions of the developing world. A large part of the population lives in informal settlements and rural areas, and the high building standards specified in the codes are simply not feasible [16][19]. Building codes specify a wide range of design and construction guidelines and standards related to safety, health, amenity and sustainability (see for example, [24]), where the safety aspects are the most crucial to protecting human lives and well-being from disasters. Indeed, the earliest versions of building codes were mainly concerned with this aspect and they were gradually expanded to include a wider set of issues [25][26]. Therefore, in the developing world context where lack of resources and other factors are barriers to implementing a comprehensive array of building codes, to begin with this most critical life-saving element makes sense, termed here as 'safe building codes' to signify building standards that specifically address disaster resilience. This term is not indicated widely in the literature, but there is a recent "Safe Building Code Incentive Act" in the USA through which the government allocates extra funding for enforcing building codes in a disaster affected or prone context [27]. The term has been adopted here to reflect the specific approach of this project to prioritise disaster resilience in buildings to avoid or minimise loss of human lives and assets. In line with the concept of "grey literature" as a non-commercial publication [28], a 'grey' handbook contextualised for Bangladesh and Nepal will comprise one of the main outputs of the project, where a suite of safe building options will be presented to match different socio-economic, demographic and geographical conditions. The lead author produced a similar document in the past to guide housing in flood-prone areas of Bangladesh [29], and the handbook in this project will build on such initiatives for a wider range of hazards and environments.

It is widely cited that disasters present an opportunity for building future resilience [17][30][31][32]. Many country-specific guidelines and initiatives for safer buildings have arisen after major disasters (for example [33][34]). In the project countries, Bangladesh and Nepal, recent massive disasters have been triggers for institutional reconsideration of the importance of building code compliance. In Bangladesh after recent building collapses, particularly the collapse of the Rana Plaza garment factory in 2013 killing and injuring many people [35], the Bangladesh National Building Code (BNBC) has been reviewed and updated, and there are moves to make it mandatory and enforced through a new regulatory authority [36]. However, the problem persists that a large bulk of buildings are built informally without permits, hence codes are difficult to enforce within the current context.

Similarly, in Nepal after the huge number of deaths and injuries in the 2015 earthquakes and destruction of more than 250,000 buildings [37], building codes have gained significant institutional attention. The National Building Code (NBC) has been revised and it is being publicised by the government that strict measures will be applied to implement it [38]. The NBC was originally developed after a great earthquake in 1988 [39], but was followed in only very few municipalities [38]; whether it will now be more widely adopted is yet to be seen. Nonetheless, there is greater international attention and local commitment evinced at this time, perhaps the early beginning of wider acceptance and compliance, which could be supported by awareness and education.

It is therefore a relevant time for research on this topic. This project thus explores ways of achieving wider implementation of safe building codes, not only in the formal sector through regulatory enforcement, but also in the wider informal building activity through voluntary compliance. Compliance is not only about development and enforcement of regulations, but a social transformation where organisations and communities appreciate the benefits of safe codes and follow them willingly (e.g. [40]), aptly termed by Johnson [19] as a "compliance culture". Various approaches are suggested to catalyse such a paradigm shift, such as incentives, tax benefits, reduced insurance premiums and reverse mortgage [17], inclusion in educational curricula and school buildings [19], contextualised approach according to country [41], sector-wide training including construction workers and informal builders [42], and perhaps most importantly, raising awareness [24]. This project examines such approaches in the context of the emerging initiatives on implementation of building codes to identify prospects for wider promotion and application for disaster resilient building practices.

3. Context of the case studies

It is understandable that developing countries such as Bangladesh and Nepal face constraints in implementing building codes. Beyond the oft-cited issues of enforcement and corruption, affordability is a key constraint for the vast bulk of the population that build informally. The codes provide a broad spectrum of good practice guidelines, often based on developed country models, and can thus be onerous and difficult to implement in their entirety in the socio-economic context of South Asia. However, the codes also include guidelines for safety to enable buildings to be

disaster resilient – these hazard-related codes can be termed as 'safe building codes' to differentiate them from codes that deal with other aspects (see for example [27]). At a bare minimum, if only the safe building codes are followed, a level of disaster resilience can be achieved.

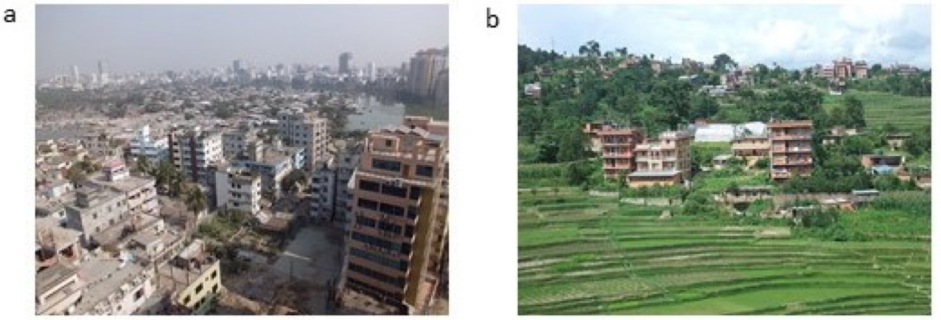

Fig. 1. Lack of compliance to safe building codes makes the rapidly growing cities in Bangladesh (a) and Nepal (b) vulnerable to disasters.

Both the project countries face disaster risk from various types of hazards including earthquakes, floods, windstorms and landslides. Nepal endured severe earthquakes recently in 2015, where the common adage "Earthquakes don't kill people, buildings do" [43] was visibly and tragically apparent. Although Bangladesh has not experienced a major earthquake in recent times, strong tremors are frequently felt, creating public fear [44]; a massive earthquake is a real and significant possibility. Bangladesh is also frequently affected by floods and cyclones, most recently in 2016 by Cyclone Roanu [45]. Both these countries are also severely threatened by climate change with increasing magnitude and frequency of disasters. New types of hazards such as extreme heat and cloudbursts [46][47] are likely to exacerbate the impact of disasters. The avoidance of building regulations and the lack of adherence to building codes mean that it does not always require a natural hazard to result in a disaster – the collapse of the Rana Plaza garment factory in Bangladesh in 2013, killing more than 1,100 mainly women garment workers and injuring another 2,500, illustrates this point [35].

The devastating, and high-profile, disasters mentioned above including the Nepal earthquakes and Bangladesh building collapse have raised local awareness on the importance of safe buildings. They have spurred significant institutional and community interest and activity in both these countries on disaster resilient construction and safe building codes, in the face of public fear and anxiety, reported in personal communications with people there. It does appear that there might be an opportunity for voluntary compliance to safe building codes beyond the necessity of policing and institutional enforcement. It is reported that some municipalities in Nepal and some real estate developers in Bangladesh are voluntarily following building codes [48][49], representing a gradual paradigm shift. It is therefore a relevant and opportune time to undertake this project with the purpose of exploring the research problem relating to understanding the opportunities and challenges of facilitating compliance to safe building codes.

4. Relevance to policy processes

Disaster resilience is of high-level policy concern in both Bangladesh and Nepal because of the frequent and various disasters that affect these countries. Bangladesh is one of the few countries in the world that has a Ministry of Disaster Management and Relief dedicated to disaster risk reduction and has a key policy instrument in this regard, the 'National Plan for Disaster Management' (2016-2020) [50]. Nepal has a Disaster Management Section in the Ministry of Home Affairs and has established key policy instruments recently including the National Strategic Action Plan for Disaster Risk Reduction (2017 – 2030) and the National Disaster Risk Reduction Policy 2017 [51].

The NSDRM specifically highlights the importance of building codes for disaster risk reduction. However, in Bangladesh the issue of building codes is dealt with by RAJUK (Capital Development Authority) under the Ministry of Housing and Public Works, and although there are recent concerns there regarding building codes for disaster resilience, it is not coordinated with the national disaster management policy. There is thus the possibility of facilitating coordination between policies for disaster risk reduction and safe building practice, which this project will be able to facilitate. In terms of safe building codes, both governments require significant and extensive inputs in

translating their policy instruments on the ground particularly to address the widespread informal sector and addressing potential disaster impacts and resilience strategies for at-risk communities. Thus, the timing and scope of this project is relevant to both country contexts as policymakers and national institutions are faced with the challenges of implementing, mainstreaming and rolling out nationwide policies. It is also opportune because of recent commitments made by both countries to the global SFDRR.

5. Research Framework

The research problem is complex, multi-faceted and deeply entrenched in socio-economic, political and cultural conditions and has grown over a long period of time. Addressing it would require social transformation of a profound nature, and currently perhaps only the small beginnings of such transformation are evident. Thus, this project is a form of 'process research'. The research question and sub-questions below are therefore not expected to provide quick-fix and easy solutions, but to identify a probable and plausible trajectory for the small beginnings of social transformation that may realise a greater and more widespread voluntary compliance of safe building codes over the long term.

5.1. The avenue of inquiry

Given the widespread lack of compliance to building codes in the case study countries of Bangladesh and Nepal and consequent disaster impacts leading to a growth of interest in safe building codes, a key research question arises, which is exploratory in nature:

> How can compliance to voluntary safe building codes be facilitated in the current contexts of Bangladesh and Nepal for increased disaster resilience?

The following sub-questions are framed to deliver an answer to the main research question:

- What are the strengths and weaknesses in terms of disaster resilience of building codes globally, and specifically in the project countries?
- What knowledge and insights can be gained from institutional and community stakeholders in the project countries on opportunities and challenges for facilitating compliance to safe building codes?
- What practice-and-policy guidelines are required to facilitate voluntary compliance and implementation of safe building codes?

5.2. Exploratory methodological approach

The project methodology is linked to the main research question and sub-questions discussed. The main research question – "How can compliance to voluntary safe building codes be facilitated in the current contexts of Nepal and Bangladesh for increased disaster resilience?" – is exploratory in nature in line with definitions of exploratory research, for example, "… an examination into a subject in an attempt to gain further insight" [52] and "… the researcher's tool to understand an issue more thoroughly" [53]. However, to seek answers to the question, a set of sub-questions are posed, that are descriptive and will allow discovery of the nature and characteristics of the phenomenon explored by the main research question. The descriptive studies will be of mixed-method, that is, they will employ a range of empirical methods including case studies, interviews, focus group discussions and workshops, utilising participatory and consultative data collection tools. Stakeholder consultations in the project countries and project workshops will be the prime vehicles for employing these methods and tools. The empirical part of the project will be substantial, informed by and positioned within global and local knowledge streams. An exploratory global literature review will cast a wide net to capture inter- and transdisciplinary perspectives.

5.3. Logical anticipation of outcomes

A 'log frame' (abbreviated from logical framework) was used to plan this project; this enabled providing an overview of the project's goals, activities and anticipated results in a matrix. This matrix structure specified the components of the project and the measures by which the anticipated results will be monitored. One of the key aspects of the matrix was to elicit the assumptions made in delivering each goal or activity.

The log frame was aligned to the below five objectives of the project:

i. A review of global literature and local literature in the project countries including building codes and regulations to identify potentials and gaps in terms of disaster resilience;
ii. Develop an understanding of challenges and opportunities for facilitating voluntary compliance to safe building codes;
iii. Produce practice-and-policy guidelines for facilitating voluntary compliance and implementation of safe building codes extending to informal sector buildings;
iv. Involve early career researchers in the project countries to meet the above objectives and thereby build local research capacity;
v. Explore possibilities of forming networks and cross-learning between the project countries and wider regional and international knowledge dissemination.

Table 1. Log frame for objective 2.

Rationale/Action(s)	Indicator(s)	Verification	Assumption(s)
Results (Objective 2)			
Develop an understanding of challenges and opportunities for facilitating voluntary compliance to safe building codes;	A minimum of 20 participants will involve in data collections consultations in Nepal and Bangladesh Ensure at least 3 stakeholder groups are involved (NGO's, Government and building owners)	UoN will have regular meetings (Skype) with BRAC University- Bangladesh and Tribhuvan University, Nepal to work through the data collection process	The stakeholders are willing to participate and they have adequate understanding of the issues and working around building codes.
Result: A detailed account of the challenges and opportunities in facilitating voluntary compliance of safe building codes in Bangladesh and Nepal	Identity at least 5 key opportunities and 5 key challenges in facilitating voluntary compliance to safe building codes in project countries	The stakeholders will be given the findings to verify the outcomes.	Stakeholders will be interested in engaging with verification.
Outputs	-		-
Output: A report on the challenges and opportunities for facilitating voluntary safe building codes	Two 30 pages reports on opportunities and challenges each for Bangladesh and Nepal. Report will identify stakeholders who are best to address the challenges and opportunities	Submission of the reports to relevant authorities/stakeholders	The relevant stakeholders who were part of the workshops will support addressing the issues and exploiting the opportunities.
Activities/Process		-	
Activity 1 Organizing consultation workshops	At least three consultation events and 10 interviews will be organized with different stakeholders	UoN will monitor the data collection	Stakeholders are keen to participate and share their experiences
Activity 2 Analyzing data collected through consultations/interviews and producing a report	Nvivo will be used to analysis the data with identifying appropriate codes	The product of data analysis will lead to a code book and subsequent abstractions will identify at least 5 opportunities and challenges	The literature has specific information about the key issues to identify gaps and perform a systematic literature review.
Activity 3 Disseminate the research findings to build a case for a policy-practice guide	Organize two workshops with at least 10 members from the key stakeholder groups	Attendance numbers to the workshop	Able to attract relevant people to attend workshops
Means/Input	-		-
Activity 1	Data collection assistants in Bangladesh and Nepal Venus for consultation, catering, audio recorders	Compliance to project budget Performance targets for project assistance in terms of searching material	The participants can be recruited with reasonable effort. Can find appropriate venues for consultations
Activity 2	Project team members and project /data collection assistances Nvivo software	1. Number of reference in the endnote (Minimum 200) 2. Analysis sheets	The consultation will lead to in-depth discussions on issues relating to voluntary code adoption
Activity 3	Four project team members, projectors, catering and venue for the workshops		There will be no unforeseen circumstances impacting on the workshop

For example, as shown in Table 1, objective 2 will deliver a detailed account of the challenges and opportunities in facilitating voluntary compliance of safe building codes in Bangladesh and Nepal. The indicators to assess its results will be identification of at least 5 key opportunities and 5 key challenges in facilitating voluntary compliance to safe building codes in project countries. The verification will be through the stakeholder feedback and endorsement. The key assumptions include that the stakeholders are willing to participate and they have adequate understanding of the issues and working around building codes. The log frame further goes to identify the outputs and three activities supporting the outputs, each of them with specific verification indicators and assumptions. Such a log frame approach

was applied to all the above five objectives to formulate a detailed operational methodology.

5.4. Capacity development for the long term

Capacity development is an important element in this project in a number of ways. Firstly, it aims to produce guidelines informed by safe building codes that will be applicable for training of local construction workers and informal sector builders, and more broadly of personnel of government agencies and NGOs involved in the disaster resilience field. Secondly, early career researchers will be engaged in all three project countries - Australia, Bangladesh and Nepal - providing a valuable capacity building opportunity through working on this regional and also international research project. And thirdly, the involvement of CIFAL Newcastle, which itself has a strong capacity development agenda, will mean that the project outcomes will be utilised for wider training and exchange of learning. CIFAL Newcastle is engaged in other capacity building initiatives in several countries in the Asia-Pacific region, therefore the findings of this project will support regional capacity building beyond the project countries. Additionally, the World Bank will support a regional workshop to disseminate the project results, which will also promote and contribute to regional capacity strengthening initiatives.

6. Conclusion

This project is situated at a complex crossroads, where nations aspire for building codes of international quality yet contain a predominance of informal settlements. Such settlements also continue to proliferate. Genuine resilience will require these countries to develop an augmented building regulation capacity (both in terms of codes/advisory documents, and implementation/compliance), and an acceptance that this will require an extended period of execution. Informal settlements will require special sensitivity in terms of political, social and economic factors, where affordability to comply with building codes plays a vital role so that efforts do not further disadvantage the most vulnerable.

Consideration will be required as to the balance between regulatory advice, policing and enforcing compliance where appropriate, and providing well-informed good practice advice for those constructing with vernacular materials and skills, where enforcing compliance could be counter-productive. Ultimately this project is intended to inform the development of such materials, and protocols for their dissemination, which would ultimately be likely to utilise the "training of trainers" model. Such an approach has great potential as the most appropriate method of increasing capacity, across diverse topics and sectors, in low-income communities.

Acknowledgements

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Compliance to building codes for disaster resilience: Bangladesh and Nepal

International Conference on Building Resilience 2017, Bangkok

- Dr Iftekhar Ahmed
- A/Prof Thayaparan Gajendran
- A/Prof Graham Brewer
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APN ASIA-PACIFIC NETWORK FOR GLOBAL CHANGE RESEARCH

- Collaborators: Bangladesh - University of Dhaka and BRAC University (Prof Humayun Kabir, Dr Mohammad Faruk); Nepal - Tribhuvan University (Dr Hari Darshan Shrestha, Mr Nagendra Sitoula).

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Research Problem

- Bangladesh and Nepal - bulk of buildings (>80%) constructed informally.
- Even in formal sector, limited adherence to building codes.
- Codes are not well-integrated into building and planning regulations.
- Building codes exist, but enforcement and compliance face challenges.
- Beyond enforcement and corruption, affordability is a key constraint for people who build informally. Need for a ‘grey’ building code.

- ‘Safe building codes’ - if only they are followed, a level of disaster resilience can be achieved.
- “Earthquakes don’t kill people, buildings do”.
- Human-induced – e.g. Rana Plaza in Bangladesh.
- Increased institutional and community awareness about building safety - opportunity for **voluntary** compliance to safe building codes.
- Already a gradual paradigm shift - relevant time for this project.

Rationale for Context Focus

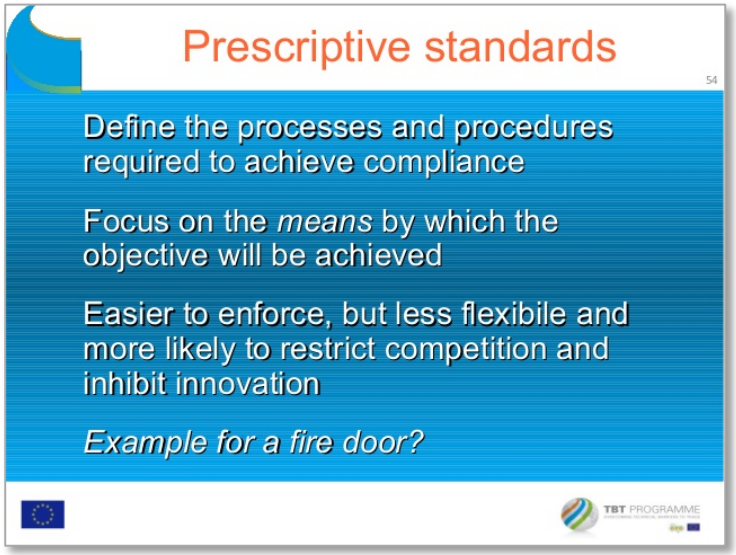
- South Asia - low economic and human development; least developed region after Sub-Saharan Africa; highly vulnerable to disasters.
- Disaster impacts in the smaller SA countries are pronounced and recovery difficult compared to India. Thus the focus here.
- Transfer of lessons and cross-learning, also be valuable for the region.
- Another ongoing project in Sri Lanka, plans to work in the Maldives.
- Long-term plan – produce a book on disaster resilience in the smaller SA countries.

Global Frameworks

- Bangladesh and Nepal - bulk of buildings (>80%) constructed informally.
- Globally, governments, international development agencies and many organisations and institutions are taking disaster resilience seriously: HFA to SFDRR.
- A priority in SFDRR: "To encourage the revision of existing or the development of new building codes and standards".
- SDGs: "Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials".
- UNISDR 'Resilient Cities Campaign': "Apply and enforce realistic, risk compliant building regulations and land-use planning principles" (UNISDR, 2010).
- Prominent international agencies eg World Bank, USAID, JICA, promote uptake, compliance and implementation of safe building codes.

Regulations: Basic Categories

- **Prescriptive regulations:**
  - ✓ Standards created to be basis for how buildings should be constructed.
  - ✓ Specifies materials, configurations and processes required to achieve the desired regulatory goal.
- **Performance-based regulations:**
  - ✓ Uses in-use performance of buildings as basis for building activities.
  - ✓ More flexible approach where only the desired regulatory goal is specified.



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Developed vs Developing Countries

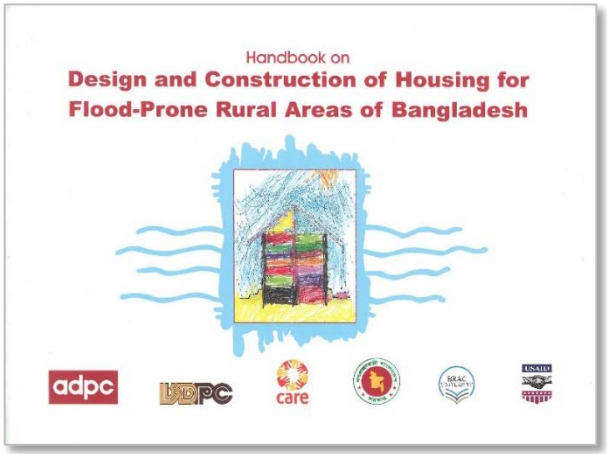
- In developed countries building codes and building regulations are integrated – include both land-use planning and building codes.
- Integration enables minimising disaster impacts, eg Japan, but took more than 70 years and a series of disasters to get to this stage.
- In most developing countries building codes are often not mandatory or limited to cities and the formal sector.
- Widely reported that enforcement and compliance of building codes face serious barriers related to governance and resource constraints, among other such factors, resulting in disaster vulnerability.

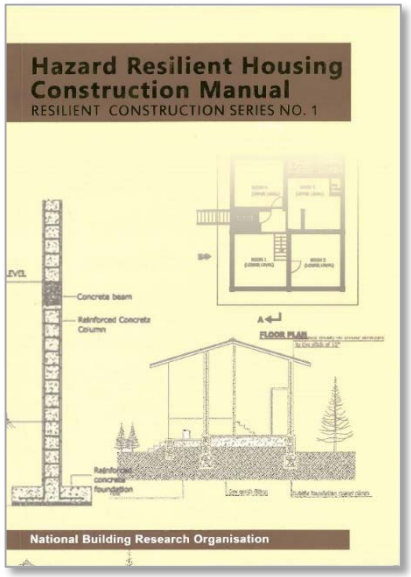
Safe Building Codes

- Building codes in developing countries have been adapted from developed countries.
- With significantly lower resources and weaker governance, codes prove difficult to implement in developing world socio-economic conditions.
- Large slum populations and rural areas, high building standards not feasible.
- Building codes specify guidelines and standards for safety, health and comfort; safety aspects are most crucial to protect from disasters.
- Earliest versions mainly concerned with safety and then expanded.
- In developing countries to begin with this most basic and critical life-saving element makes sense ('safe building codes').
- Not wide in literature, but recent "Safe Building Code Incentive Act" in USA - government allocates extra funding for enforcing building codes in a disaster affected or prone context.
- Term adopted here to prioritise disaster resilience in buildings.

‘Grey’ Building Codes

- “Grey literature” - form of non-commercial publication.
- A ‘grey’ handbook derived from the research and contextualised for Bangladesh and Nepal will comprise one of the main outputs of the project.
- Suite of safe building options will be presented to match different incomes and environmental conditions.
- Development of building codes that a suitable for the countries’ social and economic conditions and promotes the use of local materials.





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Barriers

- Weak incentives and implementation mechanisms.
- High compliance costs.
- Lack of manpower.
- Insufficient fund.
- Institutional bottlenecks.
- Corruption.
- Dysfunctional regimes and governance.
- Lack of awareness.

Opportunities

- Provision of consistent construction standards.
- Safe construction and durability of building stock.
- Psychological safety against risks.
- Proper basis and guideline for insurance services.
- Cost-effective solution to building construction.

Compliance

- Two major and conflicting philosophies address the issue of compliance:
  - ✓ **Deterrence** approach uses severe sanctions and increased cost for non-compliance.
  - ✓ **Facilitation** approach reduces the cost for compliance to allow for voluntary compliance.

Voluntary Compliance

- Widely cited that disasters present opportunity for building resilience eg “Build Back Better”.
- The problem is that a large bulk of buildings built informally without permits, hence codes cannot be enforced.
- Therefore a different approach is required to promote disaster resilience.
- Compliance is not only about development and enforcement of regulations.
- Social transformation where organisations and communities appreciate the benefits of safe codes and follow them voluntarily - “compliance culture”.

Possible Approaches

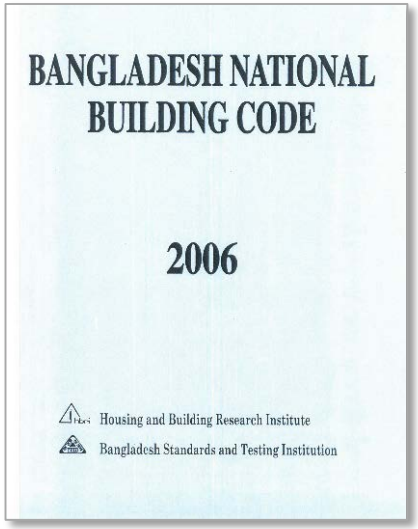
- Various approaches are suggested:
  - ✓ Incentives;
  - ✓ Tax benefits;
  - ✓ Reduced insurance premiums/reverse mortgage;
  - ✓ Inclusion in educational curricula and school buildings;
  - ✓ Contextualised approach according to country;
  - ✓ Sector-wide training including construction workers/ informal builders;
  - ✓ Raising awareness.

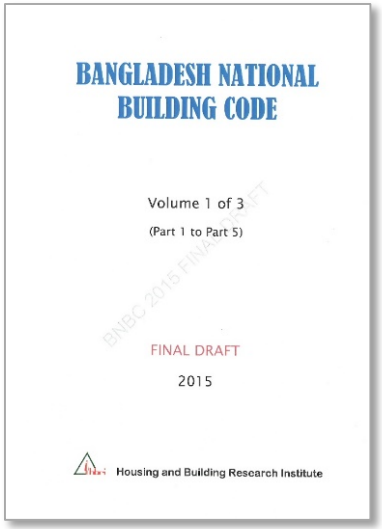
Possible Strategies

- Human Resources: Capacity building of professionals and officials.
- Enforcement Capacity: Institutional capacity to balance punitive measures with incentives.
- Cooperation among stakeholders: GO, NGO, private sector, community – participatory approach.
- Risk zonation: Restricting development in hazard zones and providing alternatives.

Bangladesh

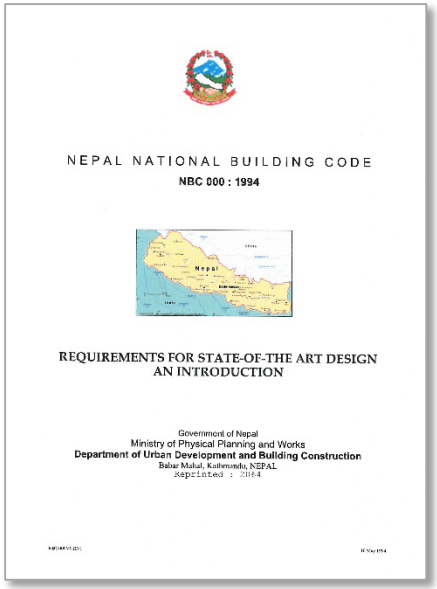
- In Bangladesh and Nepal, recent massive disasters have been triggers for institutional reconsideration of the importance of building codes.
- In Bangladesh after recent building collapses eg Rana Plaza (2013) the Bangladesh National Building Code (BNBC) has been reviewed and updated.
- There are moves to make it mandatory and enforced through a new regulatory authority. However, only in formal sector buildings.
- Even if small proportion of buildings, still a beginning and can be the basis to further extend the safe building codes agenda.





Nepal

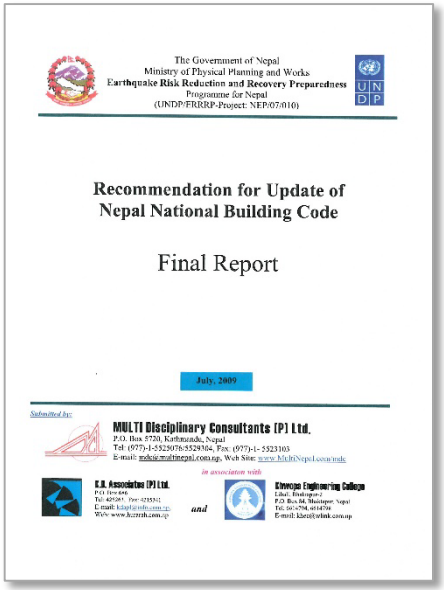
- Huge number of deaths and injuries in the 2015 earthquakes and destruction of more than 250,000 buildings.
- Building codes have gained significant institutional attention.
- National Building Code (NBC) revised and government states that strict measures will be applied to implement it.
- Developed after 1988 earthquake, followed in only few municipalities.
- Now greater international attention and local commitment.


NEPAL NATIONAL BUILDING CODE

NBC 000 : 1994

REQUIREMENTS FOR STATE-OF-THE ART DESIGN
AN INTRODUCTION

Government of Nepal
Ministry of Physical Planning and Works
Department of Urban Development and Building Construction
Babar Mahal, Kathmandu, NEPAL
Reprinted : 2064


The Government of Nepal
Ministry of Physical Planning and Works
Earthquake Risk Reduction and Recovery Preparedness
Programme for Nepal
(UNDP/ERRRP-Project: NEP/07/010)

Recommendation for Update of
Nepal National Building Code

Final Report

July, 2009

Submitted by:

MULTI Disciplinary Consultants (P) Ltd.

in association with

and

Khwopa Engineering College

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Research Framework

- Main question:

  How can compliance to **voluntary** safe building codes be facilitated in the current contexts of Bangladesh and Nepal for increased **disaster resilience**?

- Sub-questions:
  - ✓ What are the **strengths and weaknesses** in terms of disaster resilience of building codes globally, and specifically in the project countries?
  - ✓ What knowledge and insights can be gained from **institutional and community stakeholders** in the project countries on opportunities and challenges for facilitating compliance to safe building codes?
  - ✓ What **practice-and-policy guidelines** are required to facilitate voluntary compliance and implementation of safe building codes?

- Not expected to provide easy solutions - small beginning of social transformation that may realise more widespread voluntary compliance of safe building codes over the long term.

Objectives & Outcomes

- Review global literature and local literature in the project countries including building codes and regulations to identify potentials and gaps in terms of disaster resilience.
- Engage in consultations with key stakeholders at institutional and community levels to understand challenges and opportunities for facilitating voluntary compliance to safe building codes.
- Produce practice-and-policy guidelines for facilitating voluntary compliance and implementation of safe building codes extending to informal sector buildings.
- Involve early career researchers in the project countries to meet the above objectives and thereby build local research capacity.
- Explore possibilities of forming networks and cross-learning between the project countries and wider regional and international knowledge dissemination.

Log Frame Approach

Rationale/Action(s)	Indicator(s)	Verification	Assumption(s)
Results (Objective 2)			
Develop an understanding of challenges and opportunities for facilitating voluntary compliance to safe building codes;	A minimum of 20 participants will involve in data collections consultations in Nepal and Bangladesh Ensure at least 3 stakeholder groups are involved (NGO's, Government and building owners)	UoN will have regular meetings (Skype) with BRAC University- Bangladesh and Tribhuvan University, Nepal to work through the data collection process	The stakeholders are willing to participate and they have adequate understanding of the issues and working around building codes.
Result: A detailed account of the challenges and opportunities in facilitating voluntary compliance of safe building codes in Bangladesh and Nepal	Identity at least 5 key opportunities and 5 key challenges in facilitating voluntary compliance to safe building codes in project countries	The stakeholders will be given the findings to verify the outcomes.	Stakeholders will be interested in engaging with verification.
Outputs	-		-
Output: A report on the challenges and opportunities for facilitating voluntary safe building codes	Two 30 pages reports on opportunities and challenges each for Bangladesh and Nepal. Report will identify stakeholders who are best to address the challenges and opportunities	Submission of the reports to relevant authorities/stakeholders	The relevant stakeholders who were part of the workshops will support addressing the issues and exploiting the opportunities.
Activities/Process		-	
Activity 1 Organizing consultation workshops	At least three consultation events and 10 interviews will be organized with different stakeholders	UoN will monitor the data collection	Stakeholders are keen to participate and share their experiences
Activity 2 Analyzing data collected through consultations/interviews and producing a report	Nvivo will be used to analysis the data with identifying appropriate codes	The product of data analysis will lead to a code book and subsequent abstractions will identify at least 5 opportunities and challenges	The literature has specific information about the key issues to identify gaps and perform a systematic literature review.
Activity 3 Disseminate the research findings to build a case for a policy-practice guide	Organize two workshops with at least 10 members from the key stakeholder groups	Attendance numbers to the workshop	Able to attract relevant people to attend workshops
Means/Input	-		-
Activity 1	Data collection assistants in Bangladesh and Nepal Venus for consultation, catering, audio recorders	Compliance to project budget Performance targets for project assistance in terms of searching material	The participants can be recruited with reasonable effort. Can find appropriate venues for consultations
Activity 2	Project team members and project /data collection assistances Nvivo software	1. Number of reference in the endnote (Minimum 200) 2. Analysis sheets	The consultation will lead to in-depth discussions on issues relating to voluntary code adoption
Activity 3	Four project team members, projectors, catering and venue for the workshops		There will be no unforeseen circumstances impacting on the workshop

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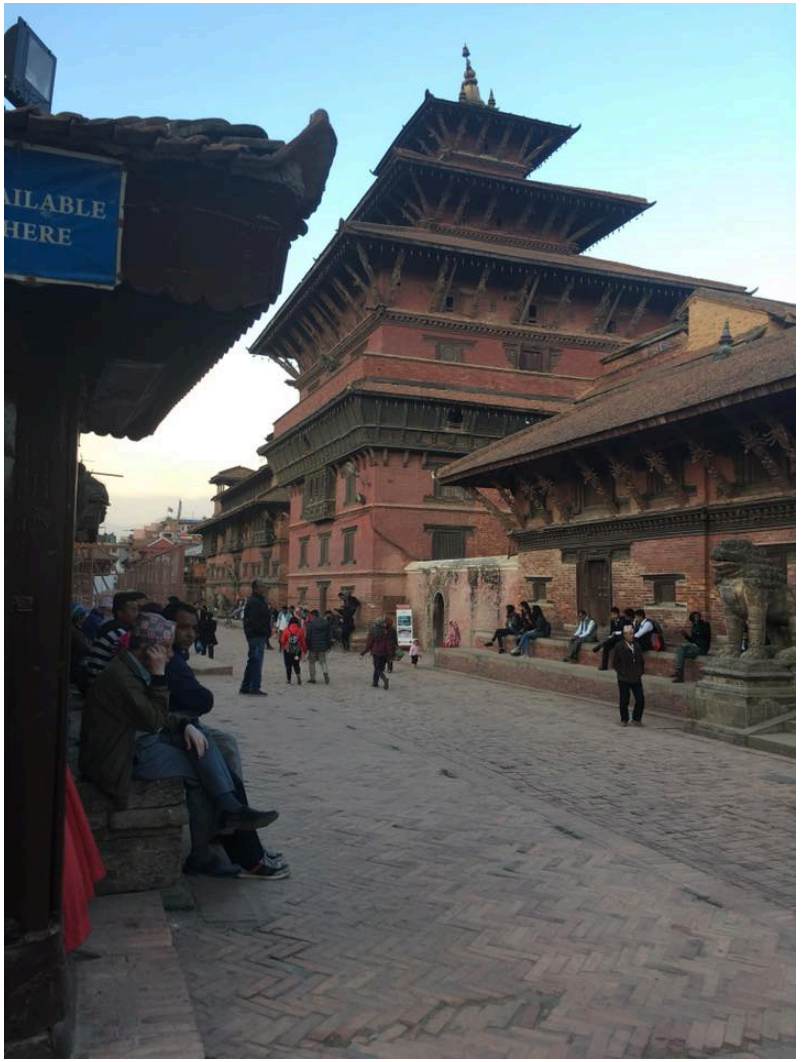
Project Planning Workshop, Kathmandu, Nov 2017



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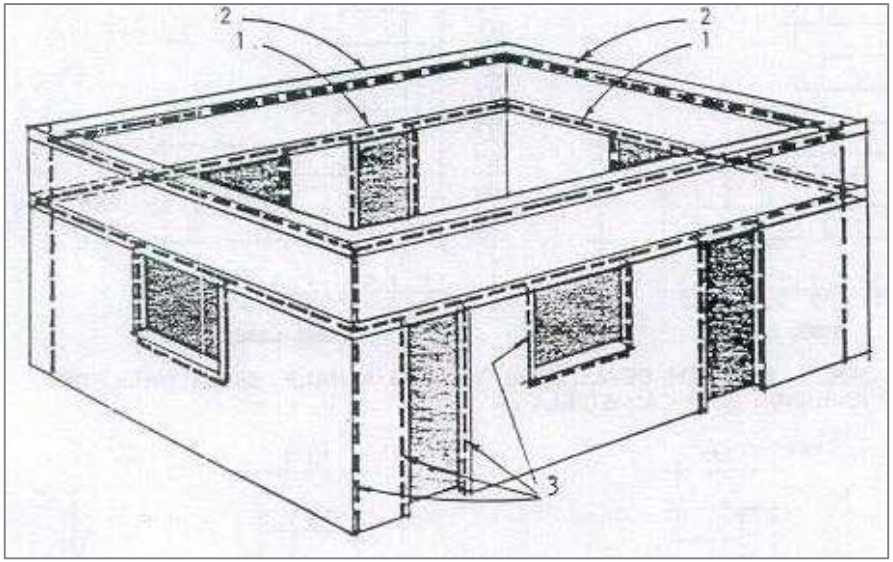
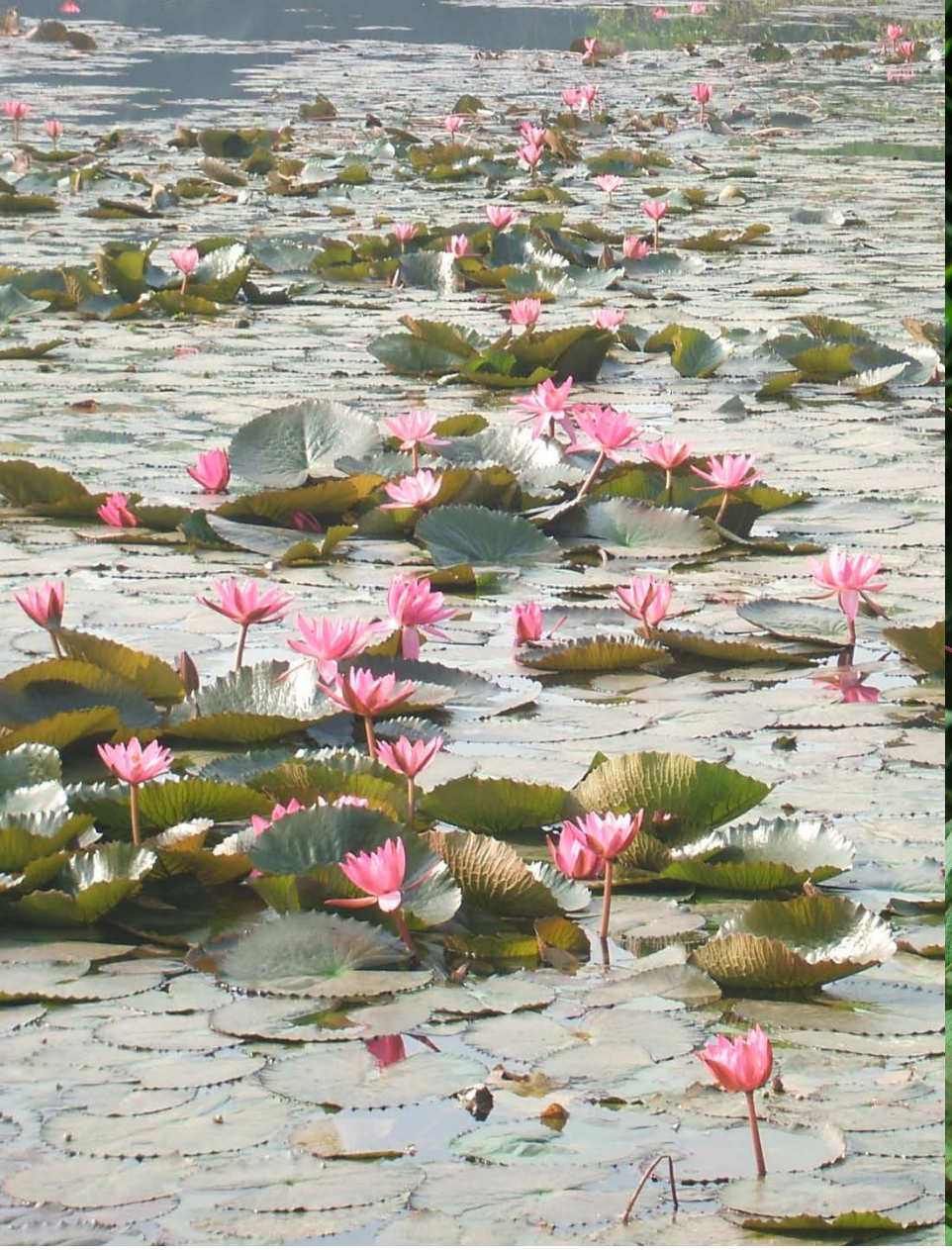
Steering the Crossroads

- Introductions between project partners and developing collaboration.
- Situated at a complex crossroads - aspiration for international quality building codes yet predominance of informal settlements.
- Balancing augmented building regulation capacity with sensitivity for informal settlements.
- Perhaps a "training of trainers" approach - great potential for increasing capacity across diverse topics and sectors, in low-income communities.





Thank You

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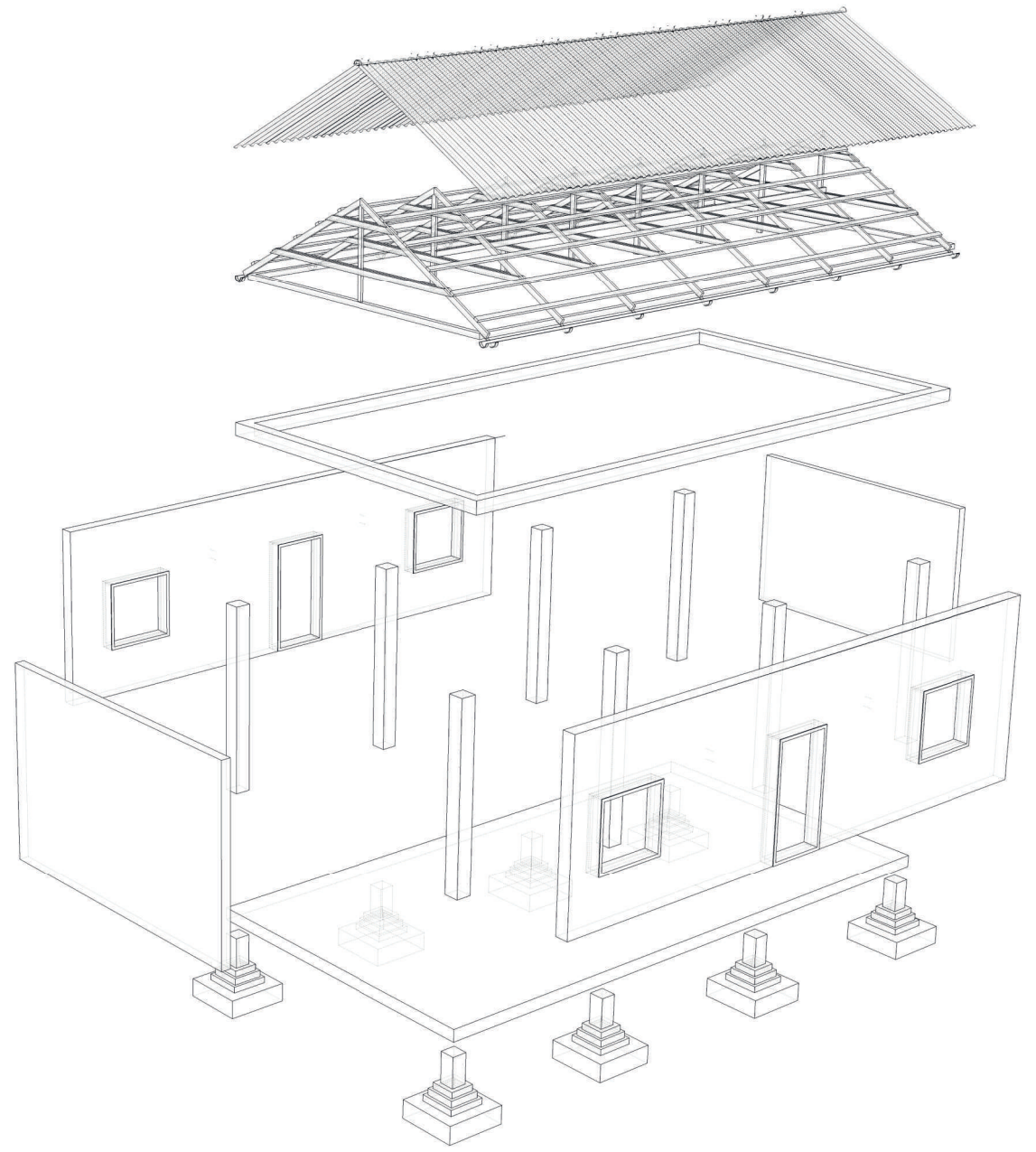
viii. Grey Building Handbook : English.



Understanding the opportunities and challenges of compliance to safe building codes for disaster resilience in South Asia

grey

BUILDING HANDBOOK

the cases of Nepal and Bangladesh

Supported by a Collaborative Regional Research Programme (CRRP) grant from the Asia-Pacific Network for Global Change Research (APN)

UNDERSTANDING THE OPPORTUNITIES AND CHALLENGES OF COMPLIANCE TO SAFE BUILDING CODES FOR DISASTER RESILIENCE IN SOUTH ASIA

the cases of Bangladesh and Nepal

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University of Newcastle, Australia
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Design of the handbook, texts and drawings by Georgia Kissa, Research Assistant, University of Newcastle Australia.

CONTENTS

PREFACE

This handbook has been produced in the Collaborative Regional Research Project "Understanding the opportunities and challenges of compliance to safe building codes for disaster resilience in South Asia - the cases of Bangladesh and Nepal" supported by the Asia Pacific Network for Global Change Research (APN). The project is led by the University of Newcastle, Australia, in partnership with Dhaka University and BRAC University in Bangladesh, and Tribhuvan University in Nepal.

The world is continually being barraged by disasters, often with the most severe impacts in developing countries. Poor populations living in unregulated settlements in these countries are disproportionately harmed and their informally constructed houses tend to be highly vulnerable. Building and land use regulation can prove to be a remarkably powerful tool for increasing people's safety and resilience and limiting the risk that they face. However, many of the building codes in developing countries have been adapted from developed countries, but having significantly lower resources and weaker governance, the codes prove difficult to implement in the local socio-economic conditions.

It is therefore relevant to explore ways of achieving wider implementation of safe building codes, not only in the formal sector through regulatory enforcement, but also in the wider informal building activity through voluntary compliance.

To support this process, this 'grey' handbook has been produced, contextualised for the local context and achievable within the socio-economic constraints of developing countries. It includes a set of options to meet varying economic and environmental conditions and extensively uses visual material for ease of communication and comprehension. The handbook is targeted primarily for the informal building sector and is expected to support capacity building at the community level.

THE PROJECT

This project explores the opportunities and challenges to compliance of safe building codes for disaster resilience in South Asia, focusing on two countries of the region, Bangladesh and Nepal. Recent disasters in both countries highlight that the problem lies in non-compliance to building codes. Building codes do exist in the two countries, but compliance is generally lacking or limited, especially in the widespread informal building sector. There is thus a need for understanding how these codes might be more widely adopted to enable disaster resilience. Collaboration between universities in these countries with experience in this field addressed this need.

NEPAL

Nepal is characterized by a rugged topography, high relief, variable climatic conditions, with complex geological features. Furthermore, it lies in the tectonically active zone. Nepal faces risk from various types of hazards including earthquakes, floods, windstorms and landslides, and has experienced numerous disasters. The impacts of disasters are enhanced due to human activities such as unplanned urbanization and inadequate construction of buildings and infrastructure. Nepal endured severe earthquakes in 2015 when many buildings collapsed, killing the people inside them.

BANGLADESH

Bangladesh is one of the world's most vulnerable countries to natural hazards and climate change. The primary threats to Bangladesh are floods and cyclones, and earthquakes and fires pose significant risk in the rapidly growing unplanned urban areas. The avoidance of building regulations and the lack of adherence to building codes mean that it does not always require a natural hazard to trigger a disaster – the collapse of the Rana Plaza garment factory in Bangladesh in 2013, killing more than 1100 mainly women garment workers and injuring another 2,500, illustrates this point.

1 *earthquake*

2 *flood*

3 *windstorm*

4 *fire*

5 *landslide*

THE HANDBOOK

This handbook provides advice, guidance and necessary information on key issues associated with building in disaster-prone areas and for the planning, siting, design and construction of housing with improved resilience to common and recurrent hazard events. It is targeted for local builders and houseowners in Bangladesh and Nepal, to promote principles of safe design and construction. It aims to minimize vulnerability to hazards, so that houses will safeguard occupants and their assets. Since many construction concepts are not easy to describe, the handbook contains illustrations of good practice to facilitate understanding and to explain how to build better.

HOW TO USE THE HANDBOOK

The judgment, experience and choice of the implementer or user would play an important role in deciding which combination of FOUNDATION, POST, WALLS and ROOFING would be suitable, thus allowing flexibility in house design user participation.

This handbook can also serve as a training manual, where the trainer should facilitate discussion among stakeholders to decide upon appropriate house designs based on assessment of the different construction options for the main parts of a house provided here.

The tables below has been prepared to assist in this process.

BUILDING STEPS

01

PLANNING

Before considering to build a house it is necessary to ascertain the suitability of the location and its environment.

TOPOGRAPHY

elevation, slope, undulations, drainage,
ground condition

SUBSOIL CONDITIONS

drainage paths, waterways, wetlands, coastline,
canalsor streams

ACCESSIBILITY

access to roads and related ground stability issues,
communication and routes for evacuation

SHAPE

select simple symmetrical shapes which minimize development of tension effects.

Square and rectangular shapes are preferable.

02

FOUNDATION

The function of a building foundation is to support the building safely distribuiting all the loads acting on the structure including the weight of the building and foundation, live loads and external loads to the ground.

Foundation shall therefore be
designed to :

1. contain any settlement in the ground with tolerable limits
2. have sufficient strength and rigidity to undergo significant deformation
3. be stable and durable

03

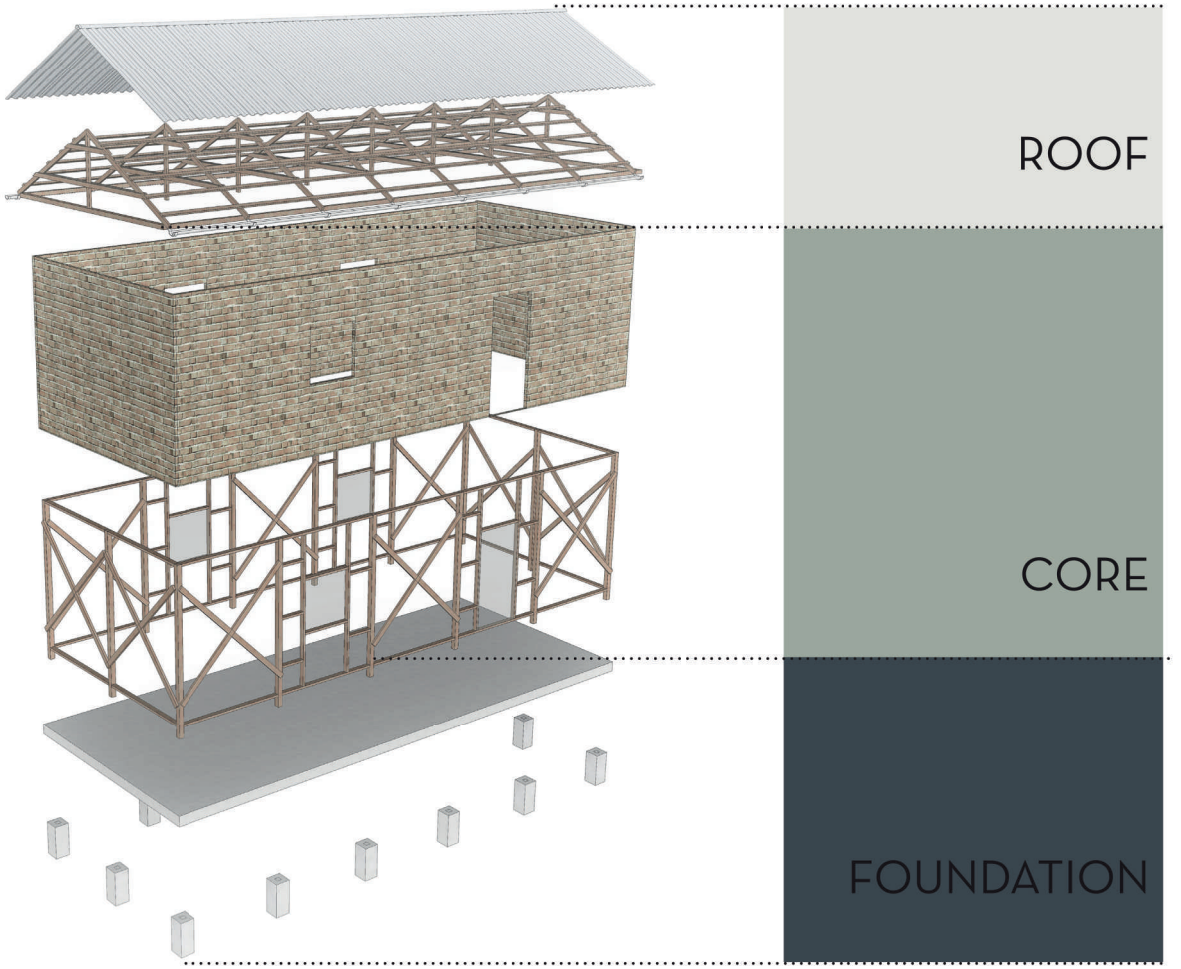
CORE

The core of the house suitable for structural loads, prevent from external conditions, provide ventilation and light.
TYPE _1
R.C. concrete frame with brick walls
TYPE_2
load bearing brick walls
TYPE _3
timber frame with earth blocks or other infill

04

ROOF

The roof may be constructed as a pitched roof with corrugated sheets or tiles as the roofing material or as a flat roof with a reinforced concrete slab.
TYPE _1
RC: reinforced concrete
TYPE_2
timber framing with CI sheets/ tiles

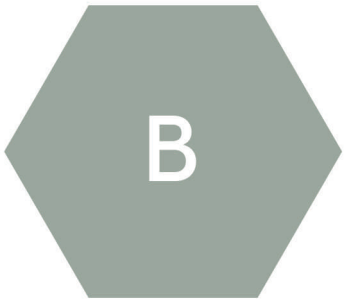


CONSTRUCTION OPTIONS

FOUNDATION

continuous

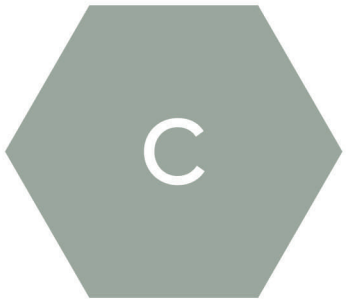
footing



POSTS

R.C. Post

timber



WALLS

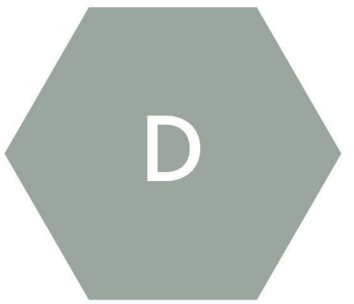
brick

concrete block

earth block

lightweight infill

bamboo



ROOFING

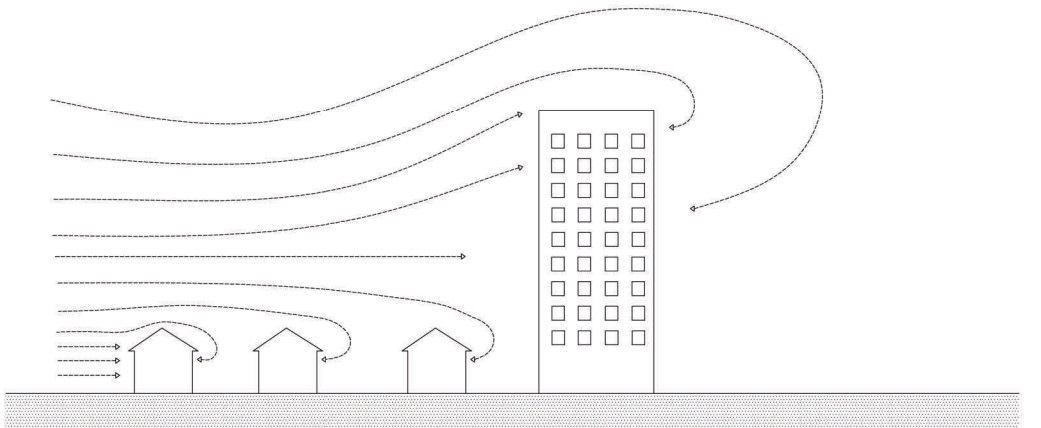
RC slab

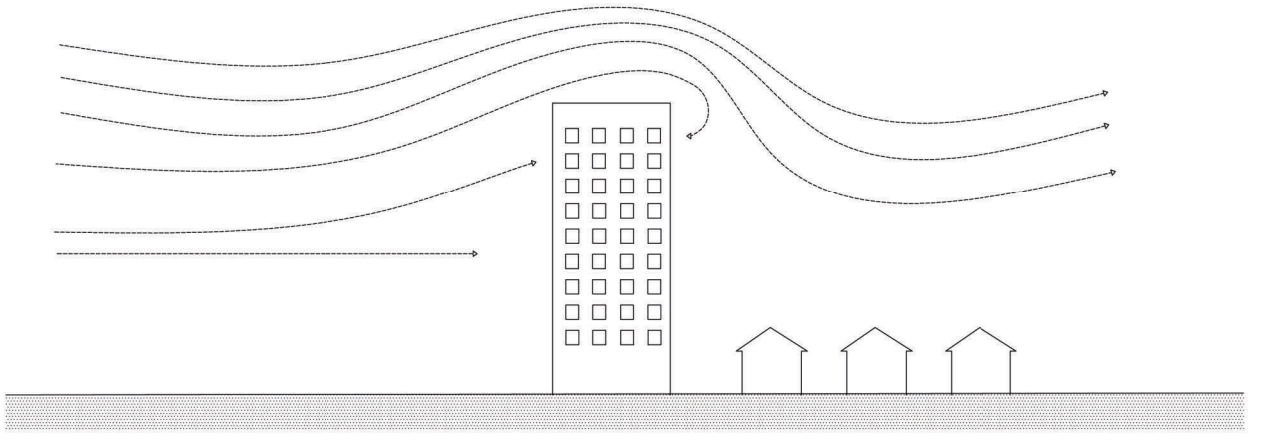
timber frame
with CI sheets / tiles

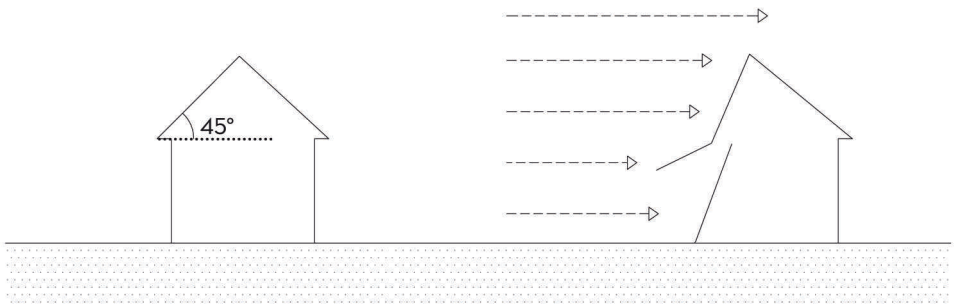
rainwater gutter

01_ PLANNING

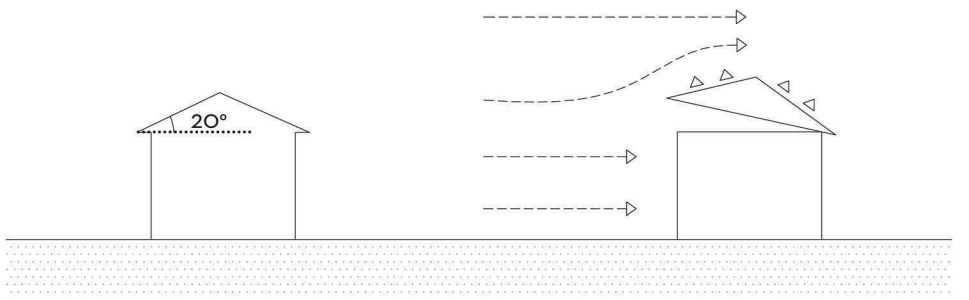
The form, degree of exposure, quality of construction, degree of structural integrity of the basic design all influence behavior of buildings under high wind stress.
Tall buildings offer some protection to lower buildings during cyclonic wind.
Site planning in cyclone-prone areas should take into consideration possibility of using tall buildings as wind breaks.
Tall buildings can be the cause of wind eddies, reverse local winds, gusts and wind shadow suction areas.
Sheltered sites reduce exposure to wind hazards. Avoid building near steep edges and steep sided valleys opening onto the sea.
Avoid linear-type development because wind forces through straight, open and parallel channels and increases in speed: “wind-tunnel effect”.



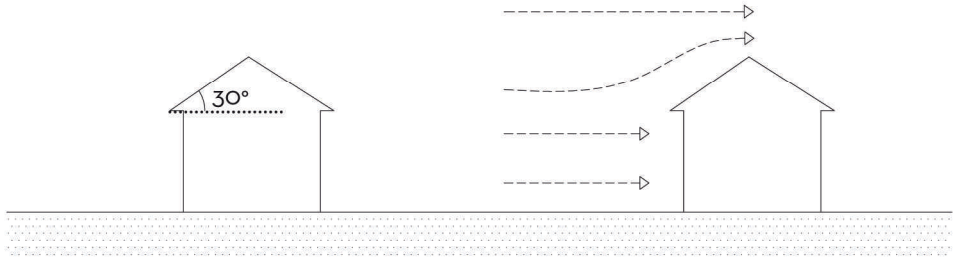




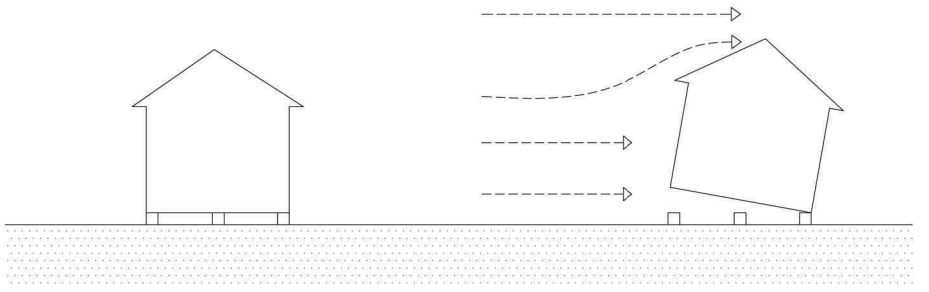
A steeply pitched roof receives high wind loading and may blow in.



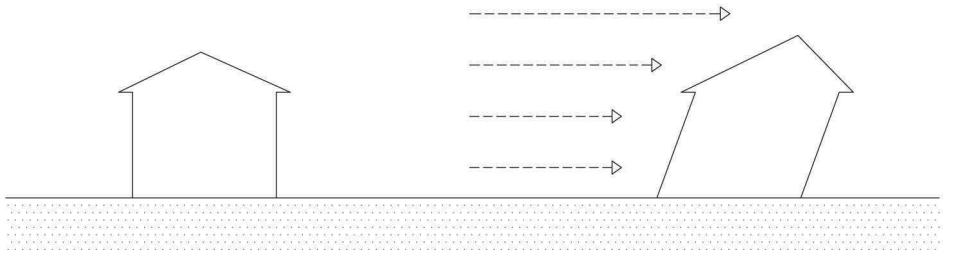
A low pitched roof receives high suction and may blow off.



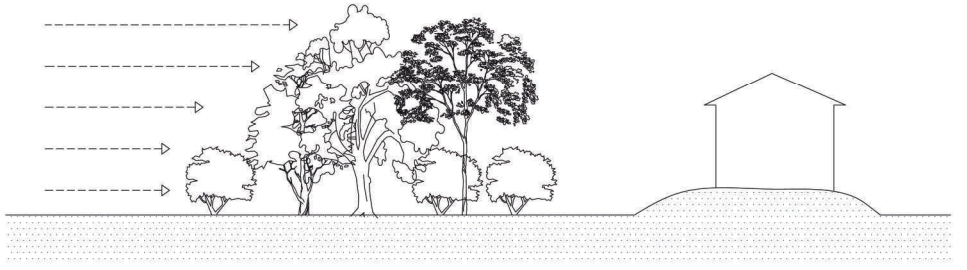
A 30° pitched roof receives least wind stress.



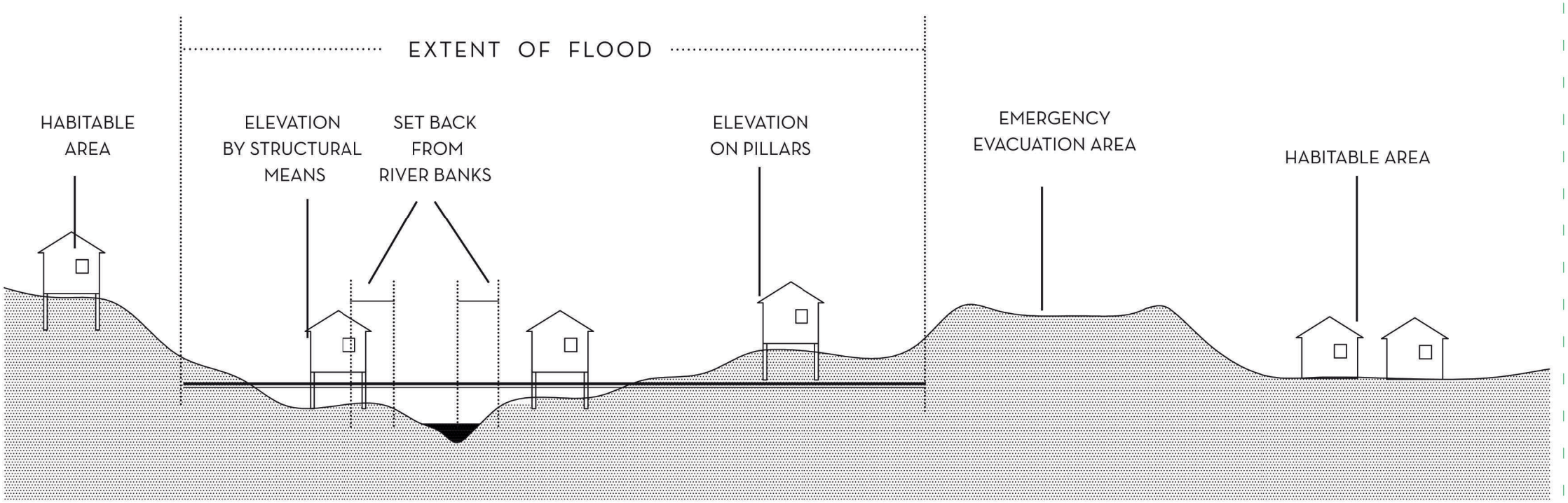
Well-constructed buildings which are not well-anchored down to their foundations may overturn.



Buildings without well-connected stiffened joints may distort.



Building shielded by vegetation placed at distance equal to tallest wind-break tree at full growth and built upon raised plinth is well-protected against wind and flood.



The choice of site for a building is mainly concerned with the stability of the ground as well as to avoid the full force of the wind or flood.

Simple rectangular shapes behave better in an earthquake than shapes with projections.

Torsional effects of ground motion are pronounced in long narrow rectangular blocks.

Therefore, it is desirable to restrict the length of a block to three times its width. If longer lengths are required two separate blocks with sufficient separation between should be provided.

Separation of a large building into several blocks may be required so as to obtain symmetry and regularity of each block.

Embankment to protect the area from cyclone storm surge and wave uprush. Rocks placed on seaward side to break wave strength. Other side to be planted with trees with deep roots to bind soil and prevent erosion.

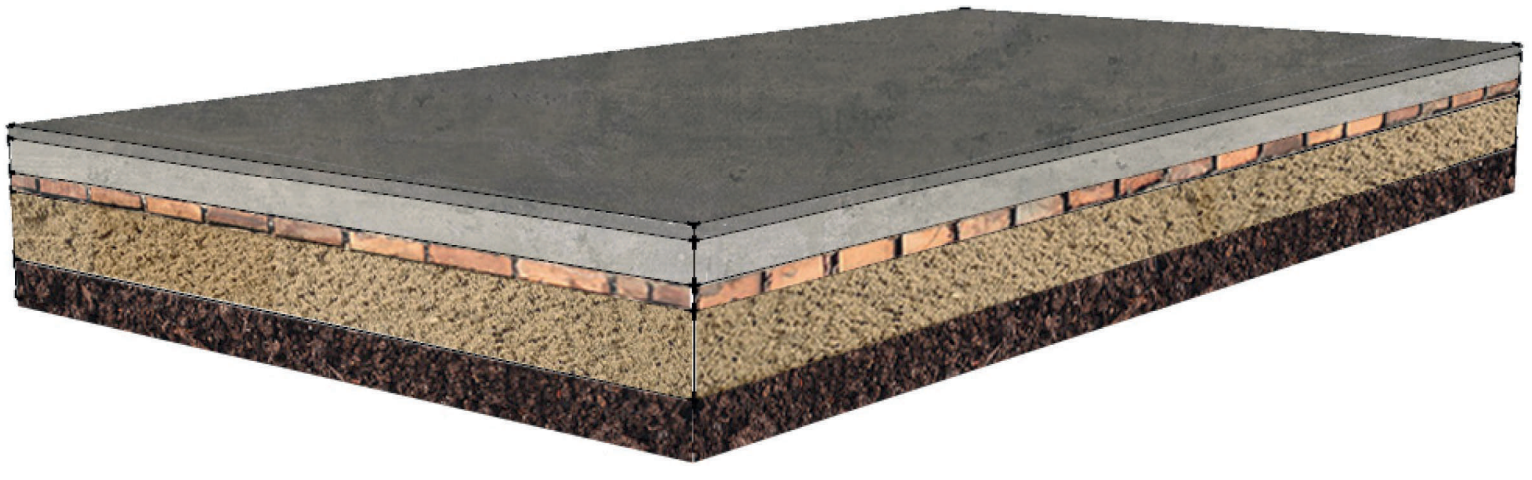
Cyclonic effect may persist inland, especially through river estuaries. May lead to flooding, therefore need for flood-proofing with emergency evacuation route and shelter zone / refuge area.

02_ FOUNDATION

A

continuous

Mixture of earth and cement to create a typical earthen plinth.
The proportion of cement should be at least 5%.
3 weeks curing by water should be done.



B

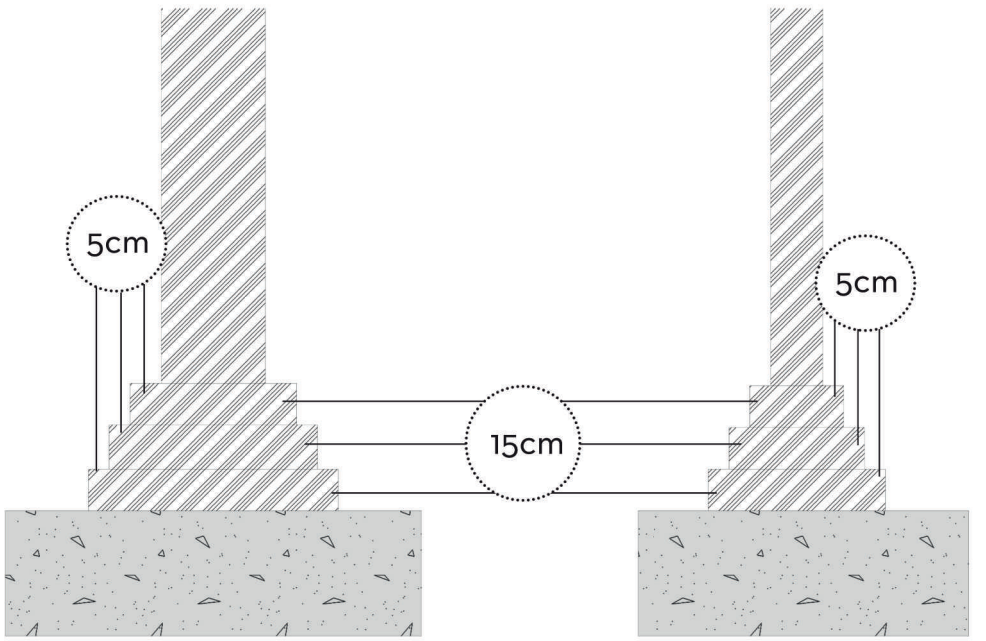
footing

COLUMN FOOTING

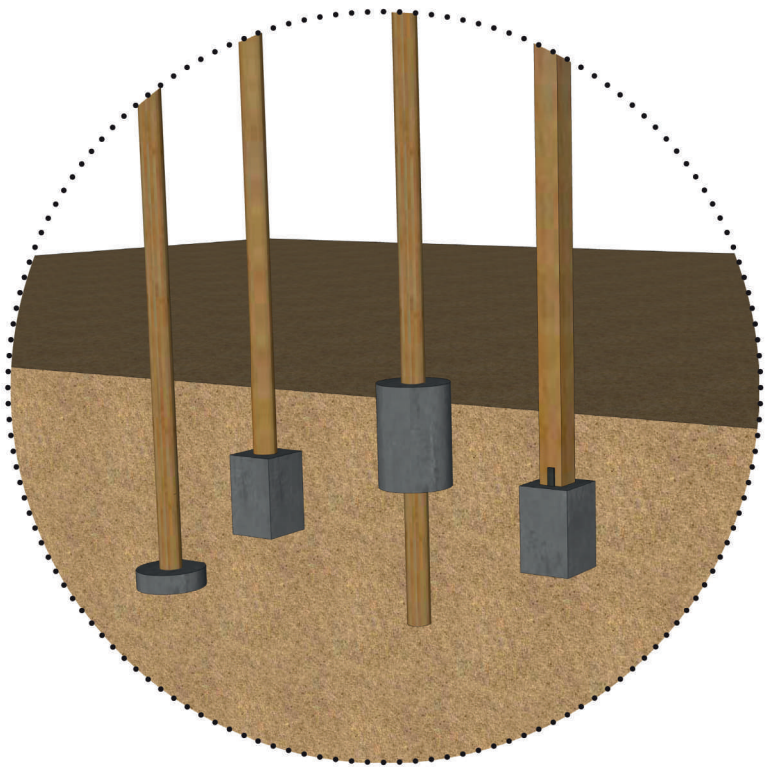
- Independent footing provided under a column.
- Distributes concentrated loads uniformly to the soil.
- Square, rectangular or circular in plan.
- Depending upon load and bearing capacity of soil, footing can be of brick or stone masonry, RC, etc.

WALL FOOTING & RC FOOTING

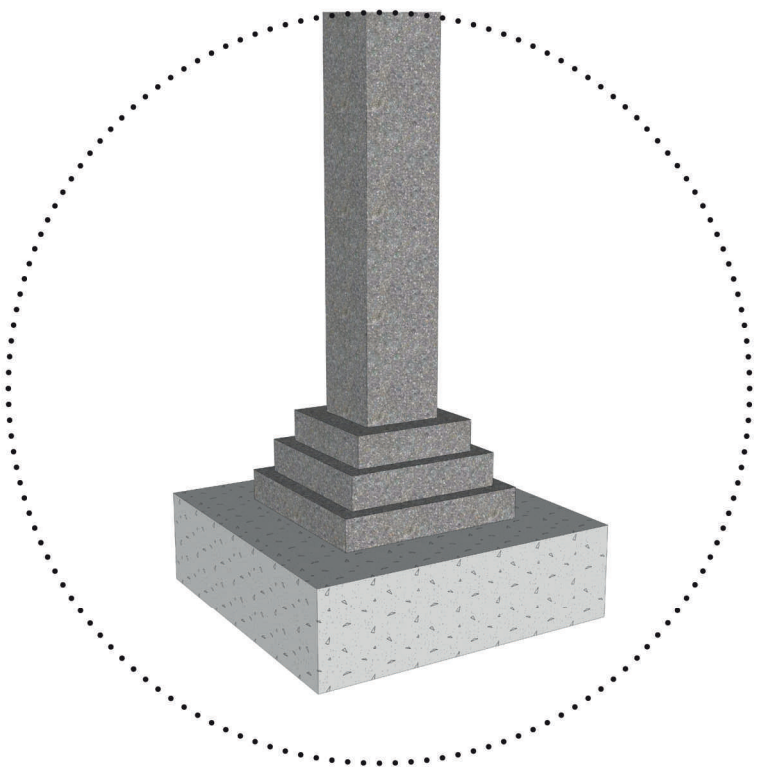
- Several courses of bricks, lowest course twice the wall thickness above.
- 5 cm offset to achieve widened base; each course 1 brick thick, in some cases bottom courses 2 bricks thick.
- Bed of lean concrete, 15 cm deep minimum, projection on each side 10-15 cm; depth of bed should not be less than its projection beyond base wall.
- Concrete bed provides a plain surface to start the wall footing; rectifies inequalities of excavation and bridges over soft patches in the soil below.
- RC footing if heavy load and bearing capacity of soil is low; otherwise massive structure is needed and would be uneconomical.
- 7-8 cm lean concrete bed below RC footing.



TYPES OF FOOTINGS



TIMBER/ BAMBOO POSTS



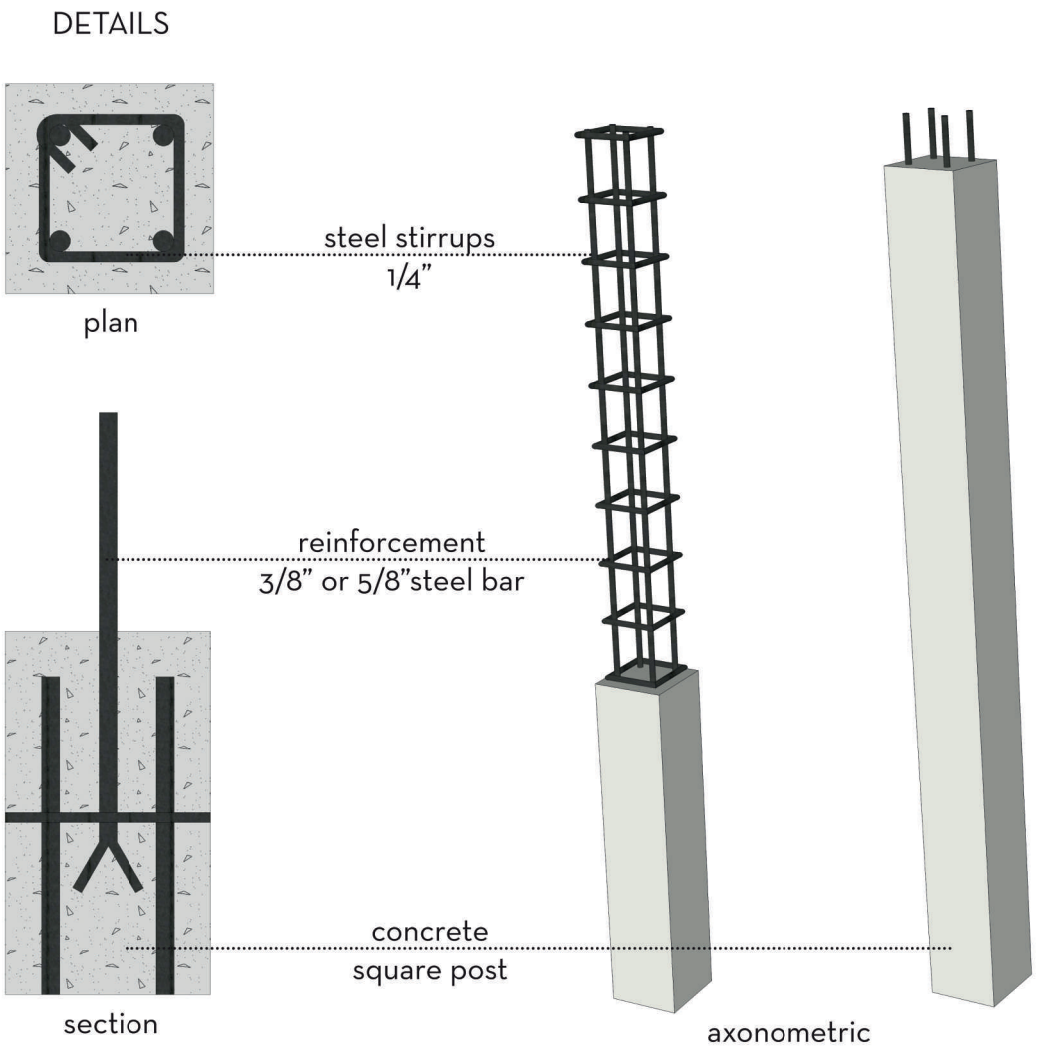
CONCRETE/ BRICK POSTS

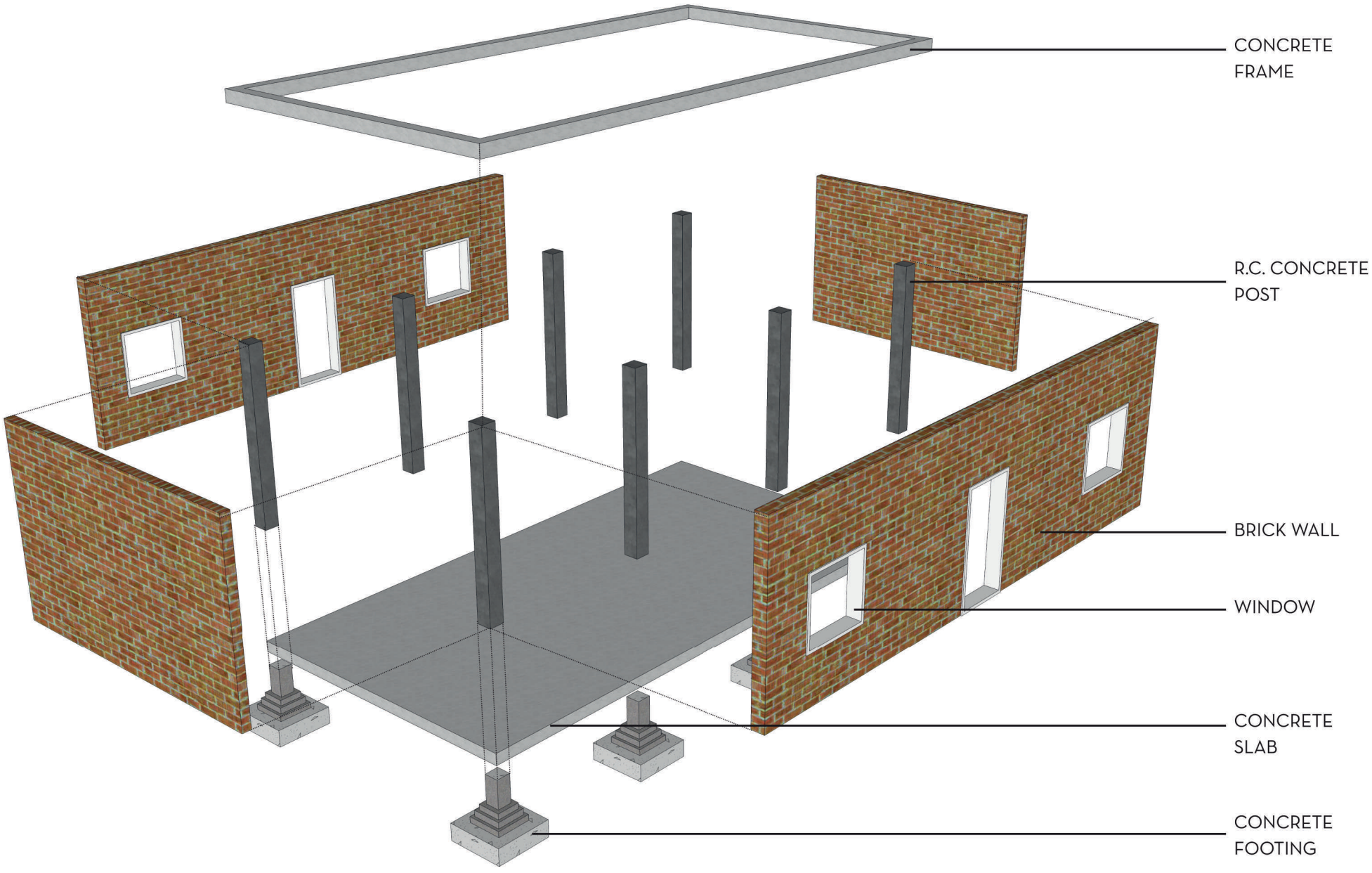
03_ POSTS

C

R.C. concrete posts

1. The proportions of the concrete mix are usually kept “1 : 2 : 3” or “1 : 2 : 4” by volume of “cement : sand : aggregate”.
2. The reinforcement may be any of the following: a) Mild steel and medium tensile steel bars. b) High strength deformed steel bars.
3. All reinforcement should be free from loose rust and coats of paints, oil, mud or any other substance which may destroy or reduce bond with concrete. Use four steel 15mm diameter re-bars, tied together with 6mm diameter stirrups and 8-10inch normal spacing.
4. Square post shape at least 20x20cm and distance between them not more than 3m.
5. Concrete frame needed to bond the walls and used as a base for the roof. Otherwise a roof slab could function as well.
6. Perimeter concrete banding on top of openings.





04_ WALLS

A

load bearing walls

Masonry strengthened by mild steel bars, hoop iron, expanded mesh or bars. Resistant to tensile, compressive and shear stresses.

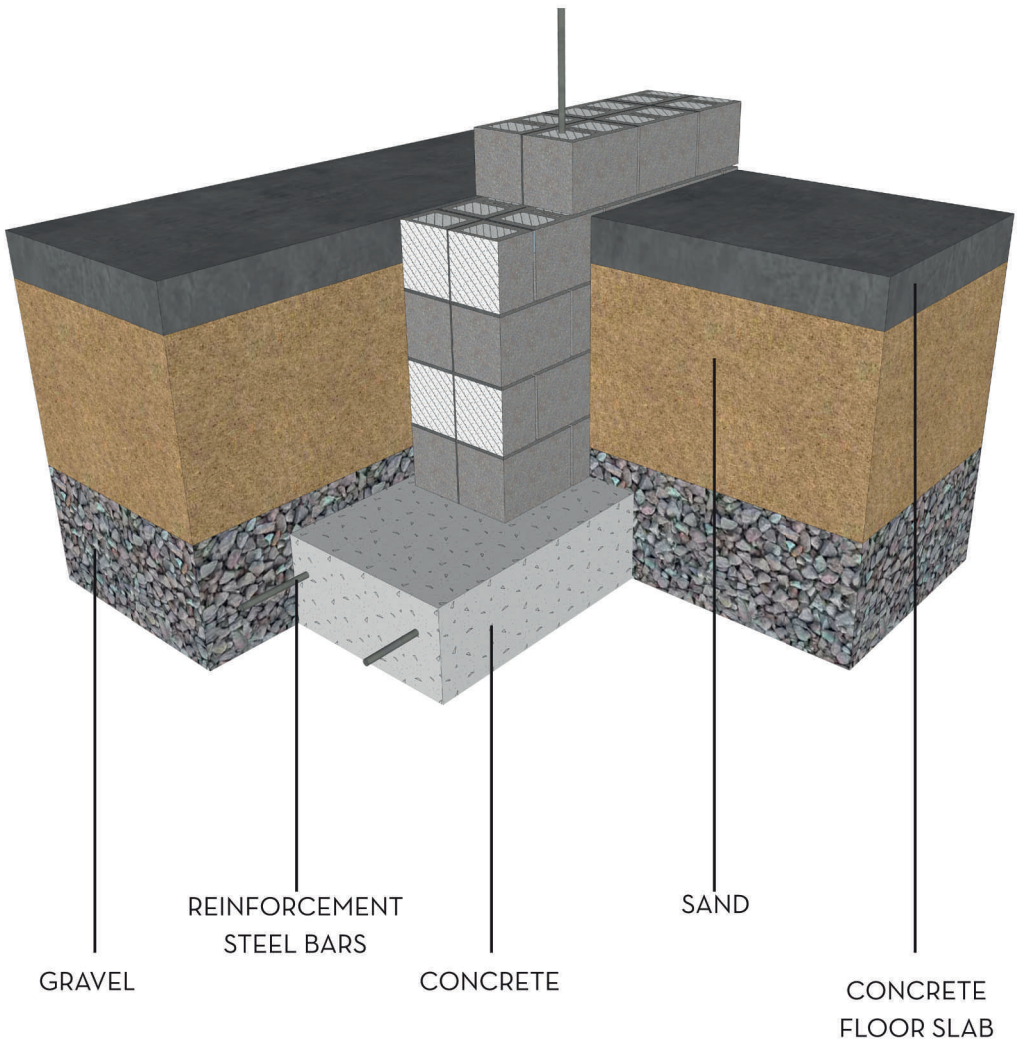
Ability to resist lateral forces: seismic and cyclonic areas.

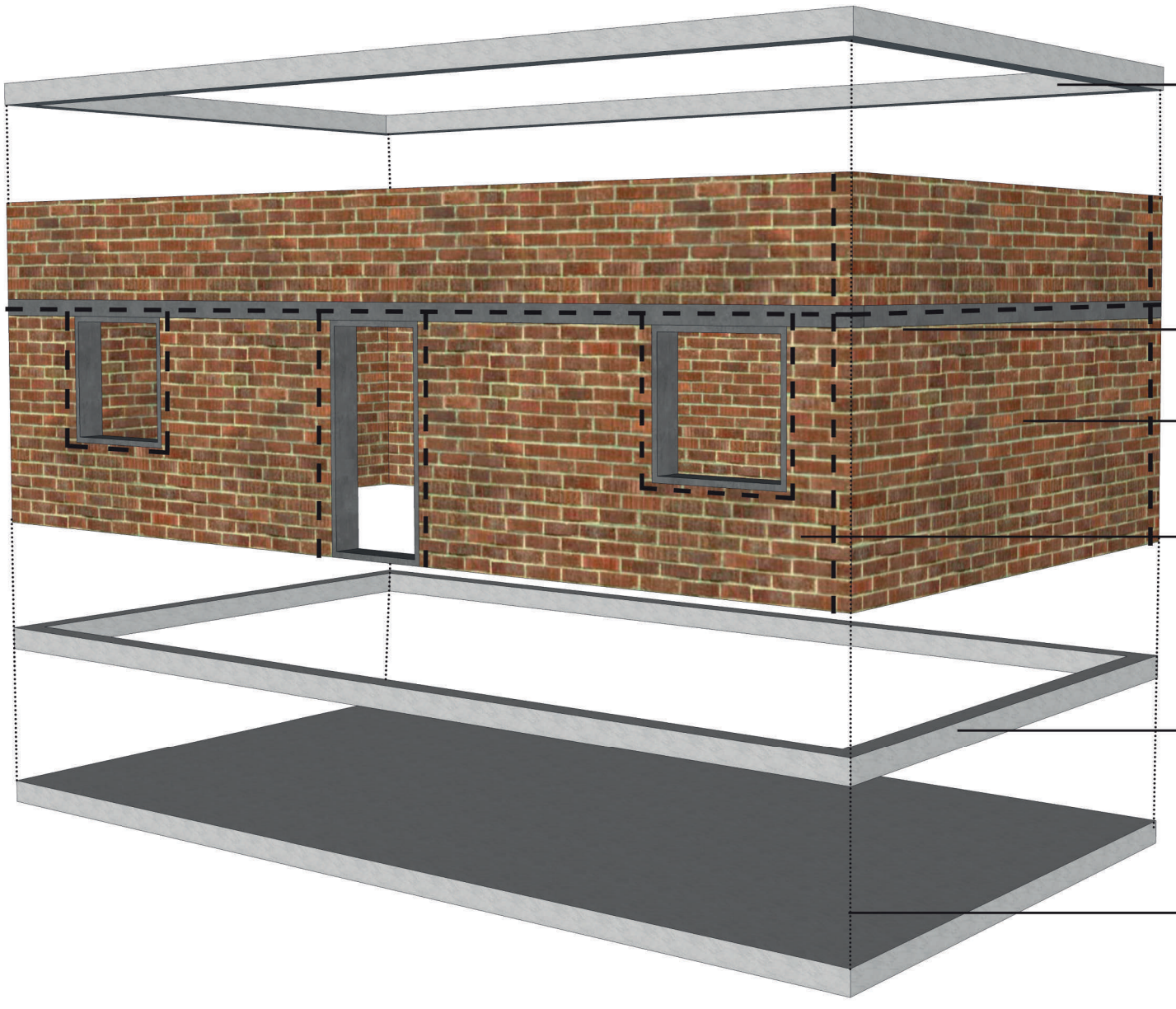
For long walls without junctions or openings, reinforced sections constructed at intervals <1.2m for hollow block, 2.0m for solid block walls.

15-25 cm cover around reinforcement for corrosion prevention.

Also reinforced brick columns and floor slabs.

Concrete strip footings for masonry walls with reinforcing bars at every corner and intersection between walls, each corner of doors and large openings and intermediate positions <1.2m apart.

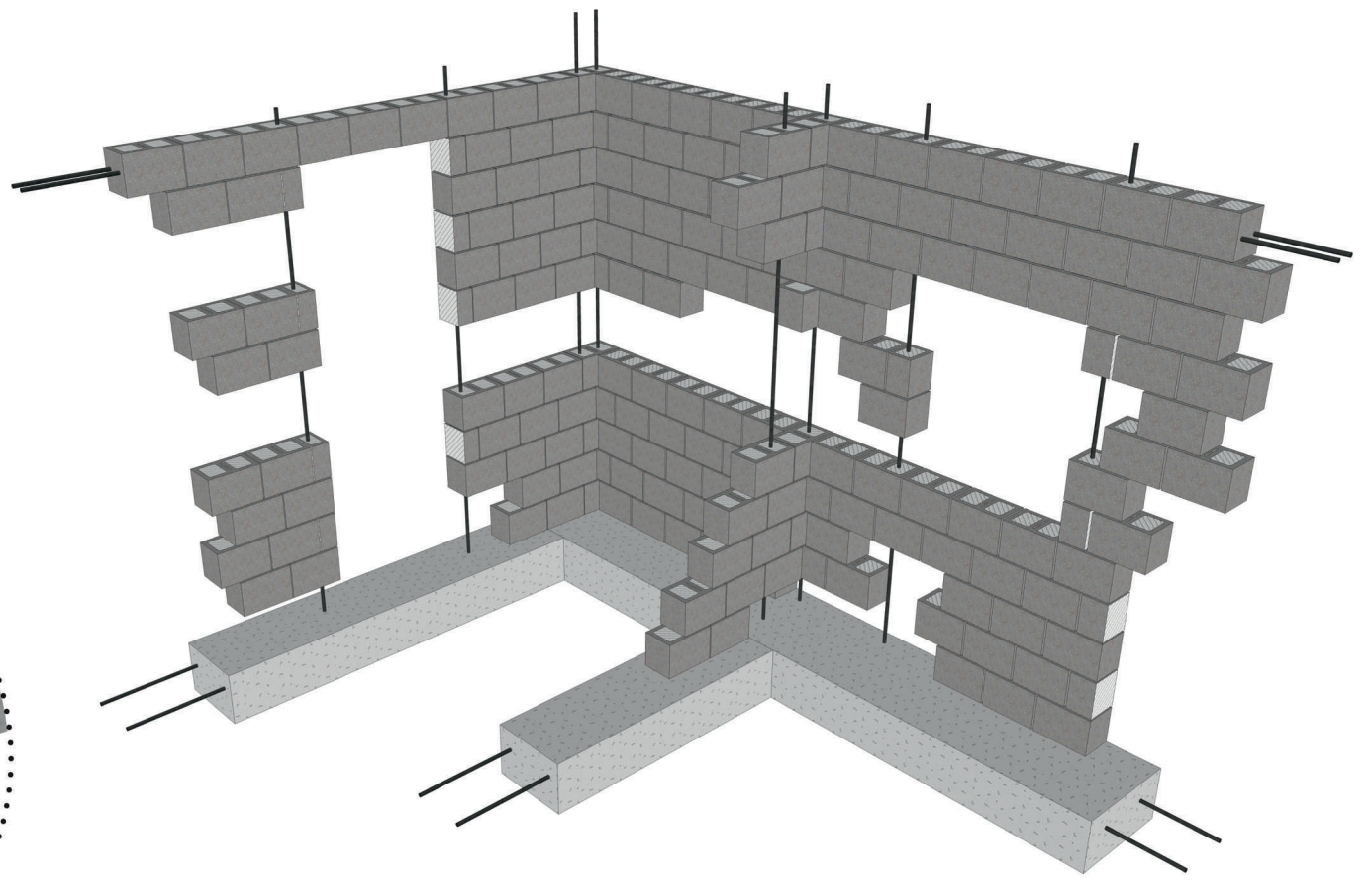


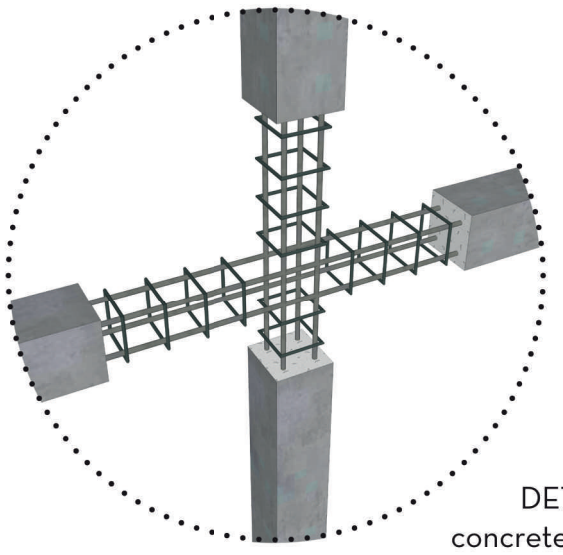


B

reinforced masonry

Masonry walls must be reinforced at all corners and junctions and sides of doors and window openings.
Strengthening masonry buildings against earthquakes by providing horizontal and vertical reinforcement.





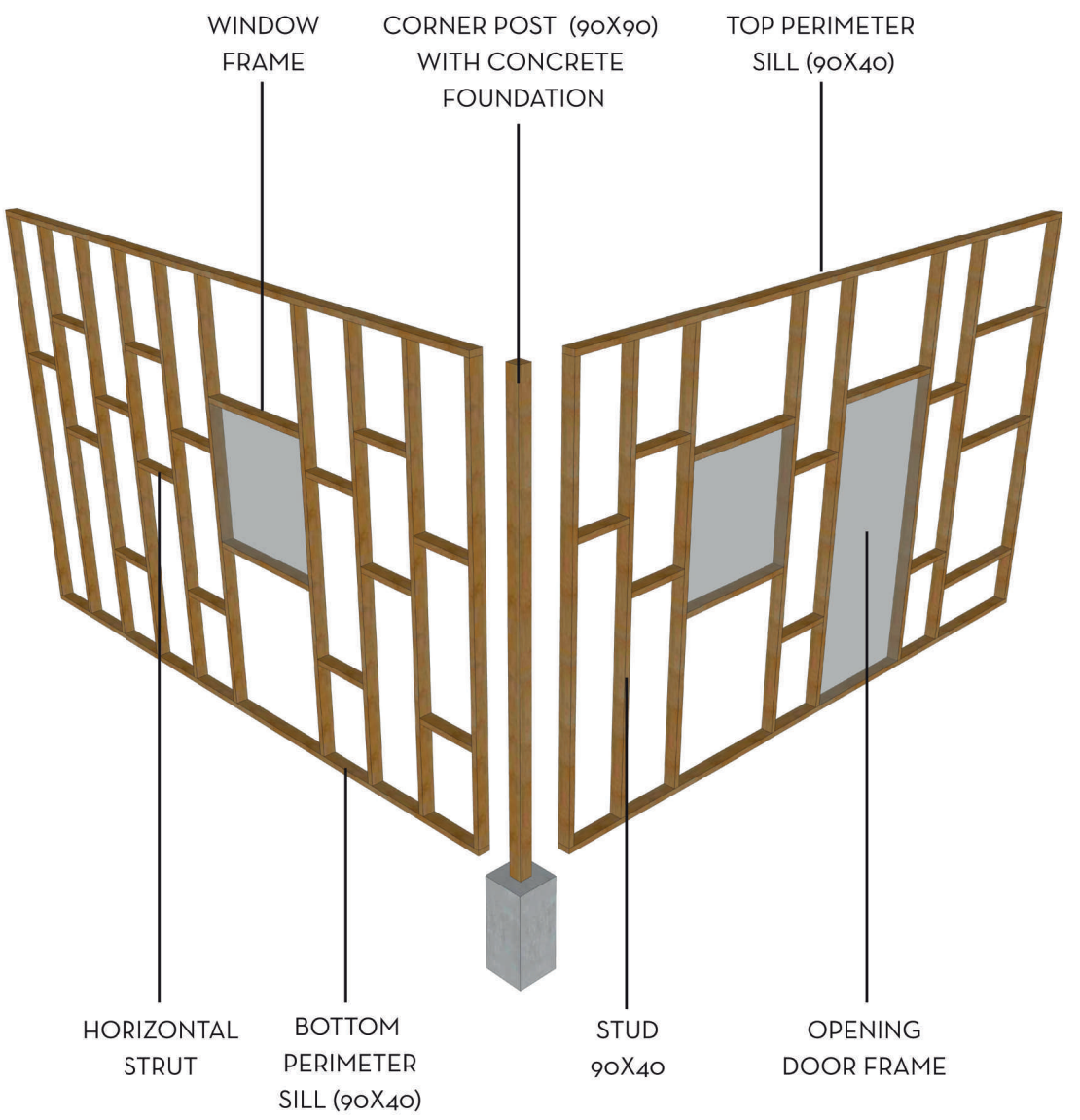
DETAIL
concrete joint with reinforcement

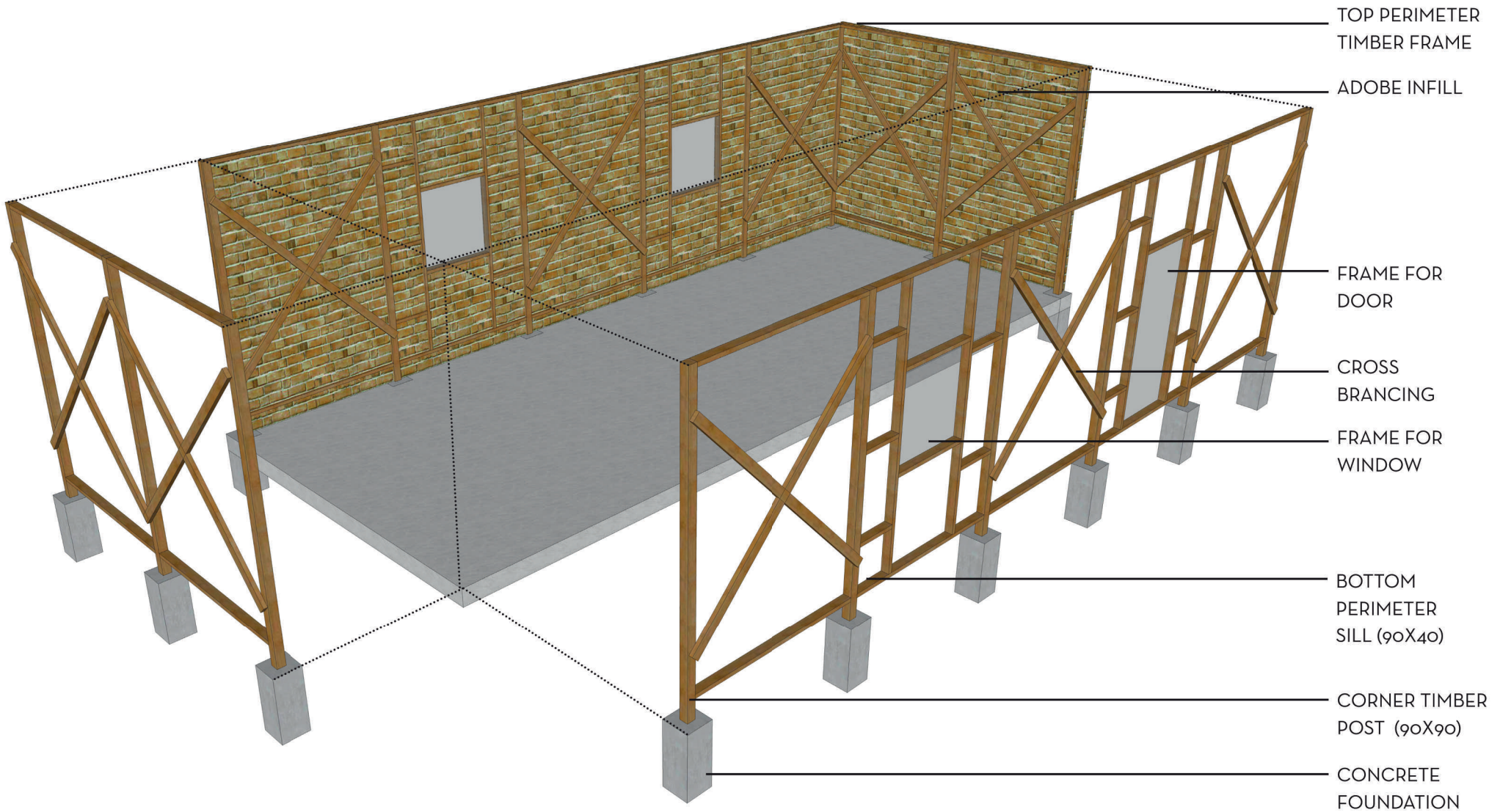
C

timber frame

Stud-wall construction consists of timber studs and corner posts framed into sills, top plates and wall plates. Horizontal diagonal braces are used to stiffen the frame against lateral loads due to earthquake and wind. The wall covering may consist of matting made from bamboo, reeds, and timber boarding or the like.

1. The dimension of the sill is 40 x 90 mm, 90 x 90 mm or larger. The sill is connected to the foundation by anchor bolts whose minimum diameter is 12 mm and length 350 mm. The anchor bolts are installed at both sides of joints of sills and at the maximum spacing is 2 m.
2. The minimum nominal dimension of studs is 40 x 90 mm. The maximum spacings of these studs vary from 0.5 to 1. If studs are 40x90 then spacing should be 0.5m , if 90 x 90 mm studs are used the spacing may be doubled, but the interior or exterior linings might need to be thicker.
3. Storey height should not be more than 2.7 m. For 2 storey houses studs should be placed every 0.5m.
4. The tops of studs are connected to top plates whose dimension is not less than the dimension of the stud.
5. Wall framing consisting of sills, studs and top plates should have diagonal braces, or sheathing boards so that the framing acts as a shear or bracing wall. In case no sheathing boards are attached, all studs should be connected to the adjacent studs by horizontal blockings at least every 1.5 m in height.





05_ ROOF : BASIC PRINCIPLES

aerodynamic roof form

1. Roof pitch 30-4-0 degrees to reduce effects of suction and uplift.
2. Hipped instead of gable roof. If gable, then end tied down firmly to rest of structure. Lean-to should be avoided.
3. Overhang < 2'-6", vents in roof and masonry parapet.
4. RC roof provides superior protection. Need for adequately braced.

roof connected to structure

1. Rafters at recommended spacing
2. Cross brancing in plane of roof and ceiling.
3. Strong connections between roof and vertical structure. Metal straps, bolts with washers on both ends instead of simple nails.

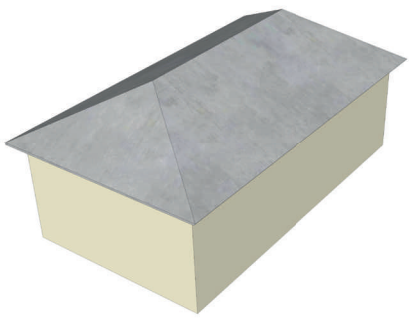
well- fixed roof covering

1. CI sheet screwed at every corrugation. Tiles fastened individually.
2. Use of J- hook bolts and threaded / twisted roofing nails.

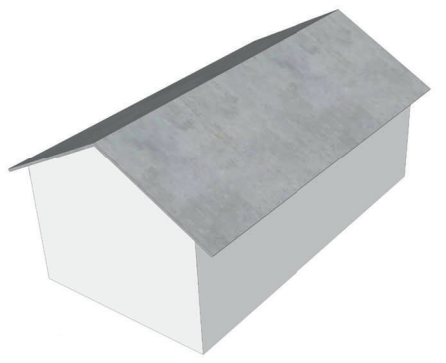
regular maintenance

1. Should make regular checks, especially around ridge and corners
2. Replace weakend members and repair loose members.
3. CI sheets should be tied strongly to structural frame to resist uplift by strong wind.

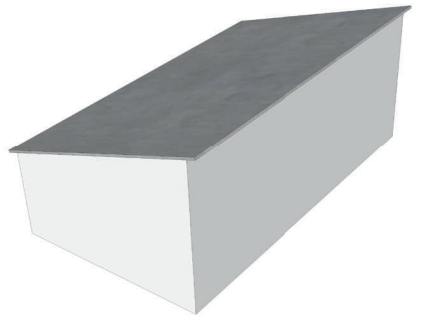
SHAPES OF ROOF



hipped roof



gable roof



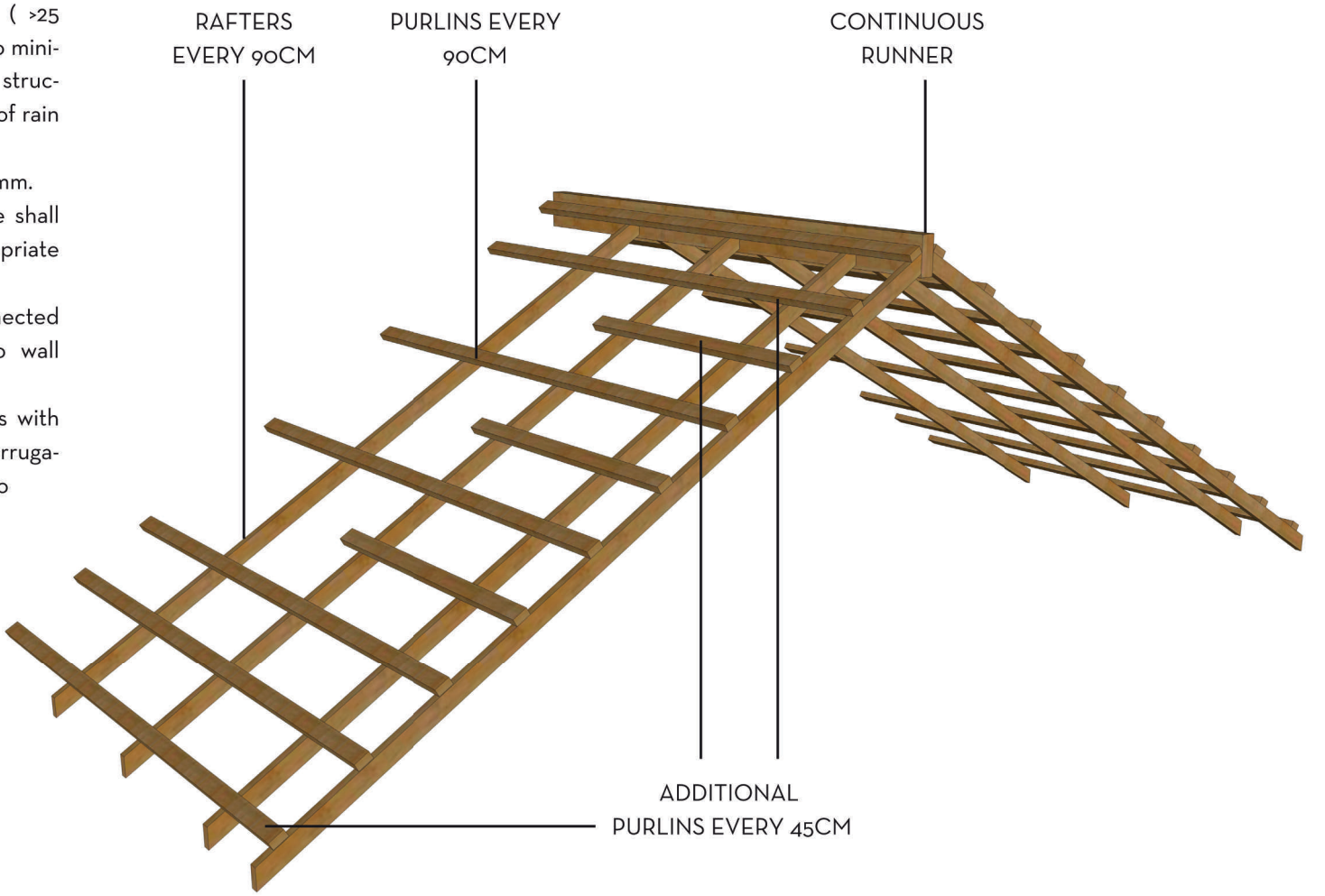
lean-to roof

A

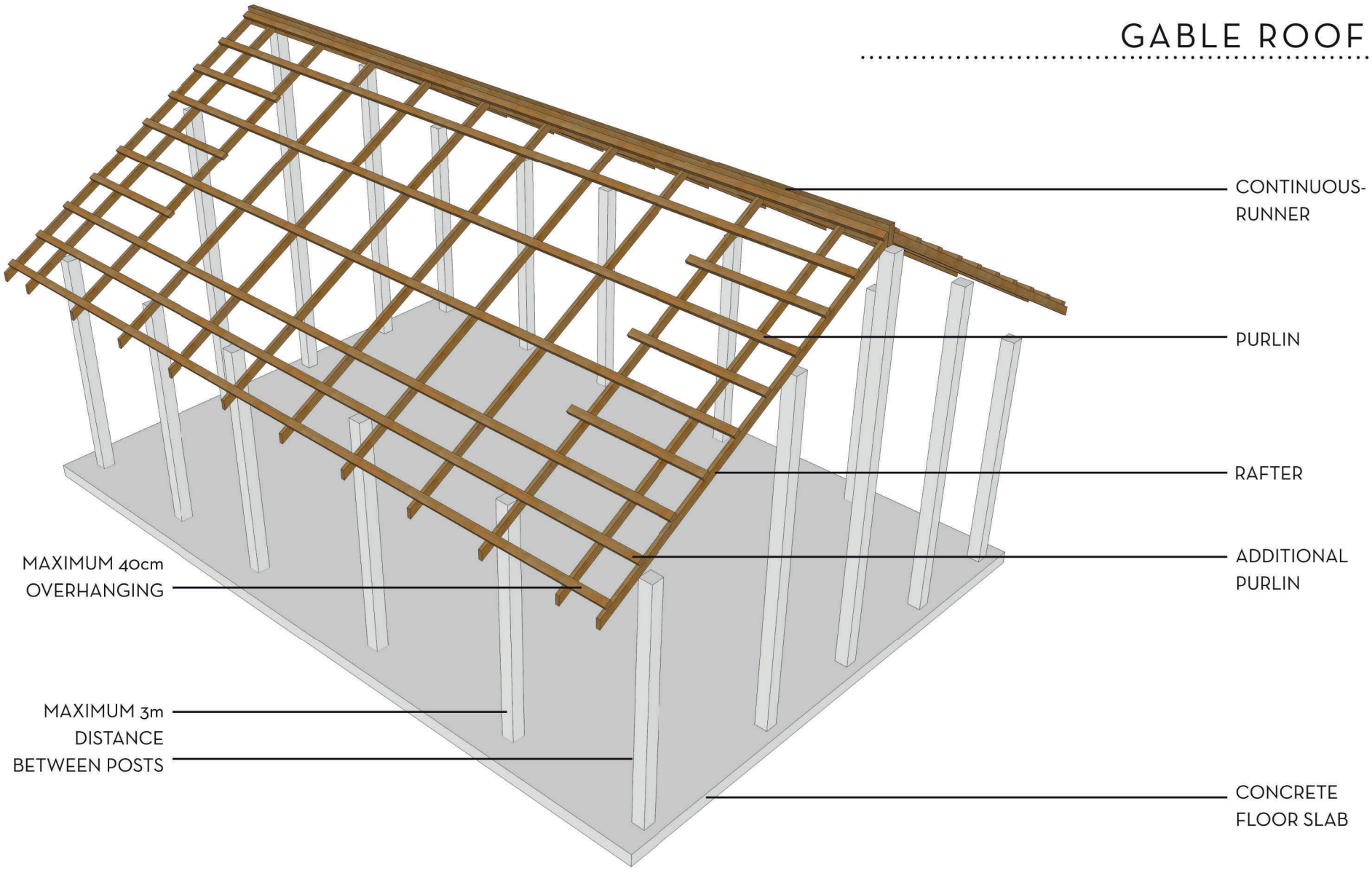
timber frame structure

Pitched roofs with adequate slope (>25 degrees) shall be provided in order to minimize uplift forces acting on the roof structure and to provide proper drainage of rain water.

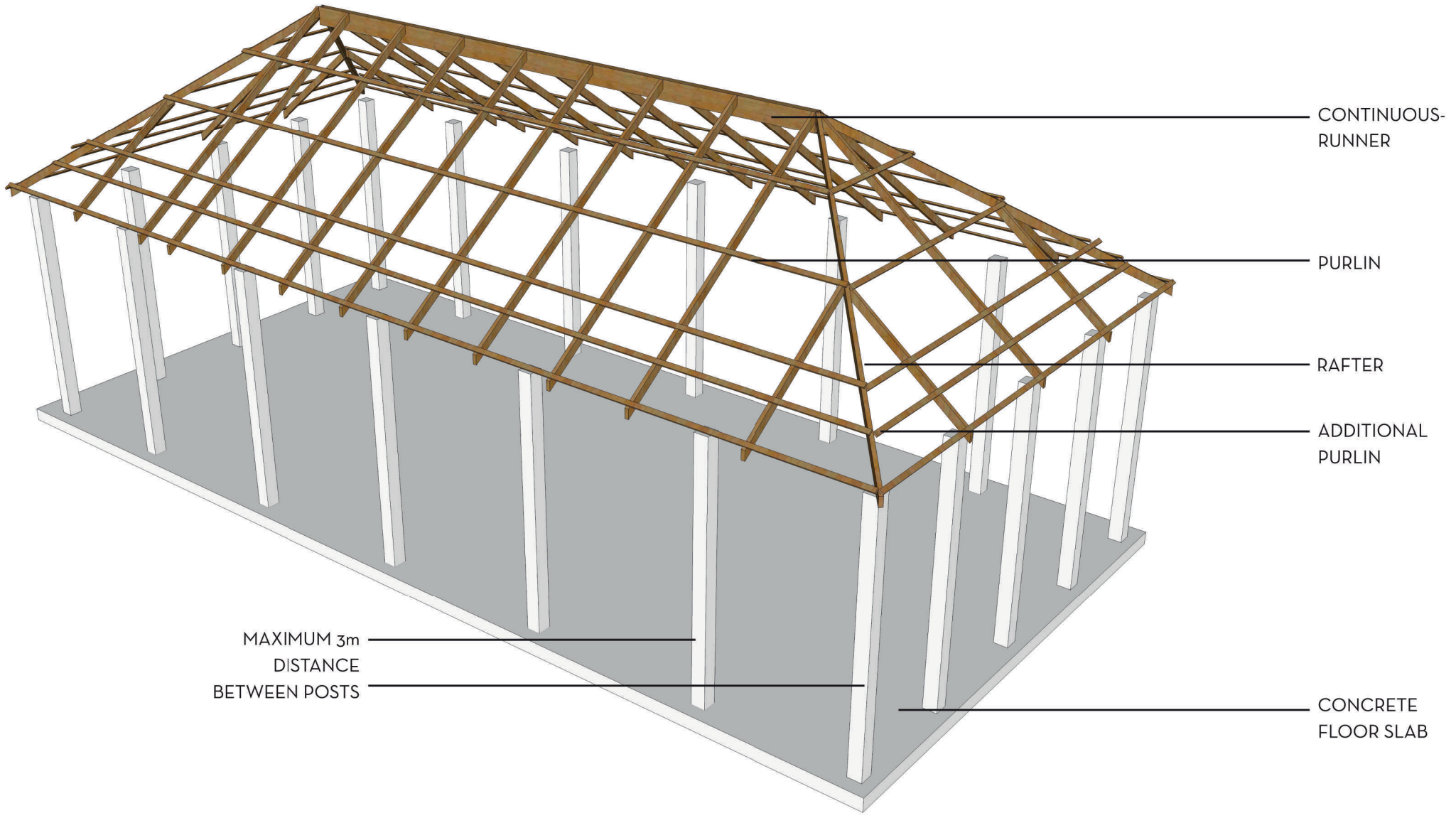
1. Maximum overhang should be 600mm.
2. Timber used in the roof structure shall be hardwood treated with an appropriate wood perservative.
3. Roofing elements should be connected properly: purlin to rafter, rafter to wall plate, wall plates to posts.
4. Every sheet to be fixed to purlins with hook bolts or twisted nails at each corrugation. More frequent fixings at edges to prevent uplift.



GABLE ROOF

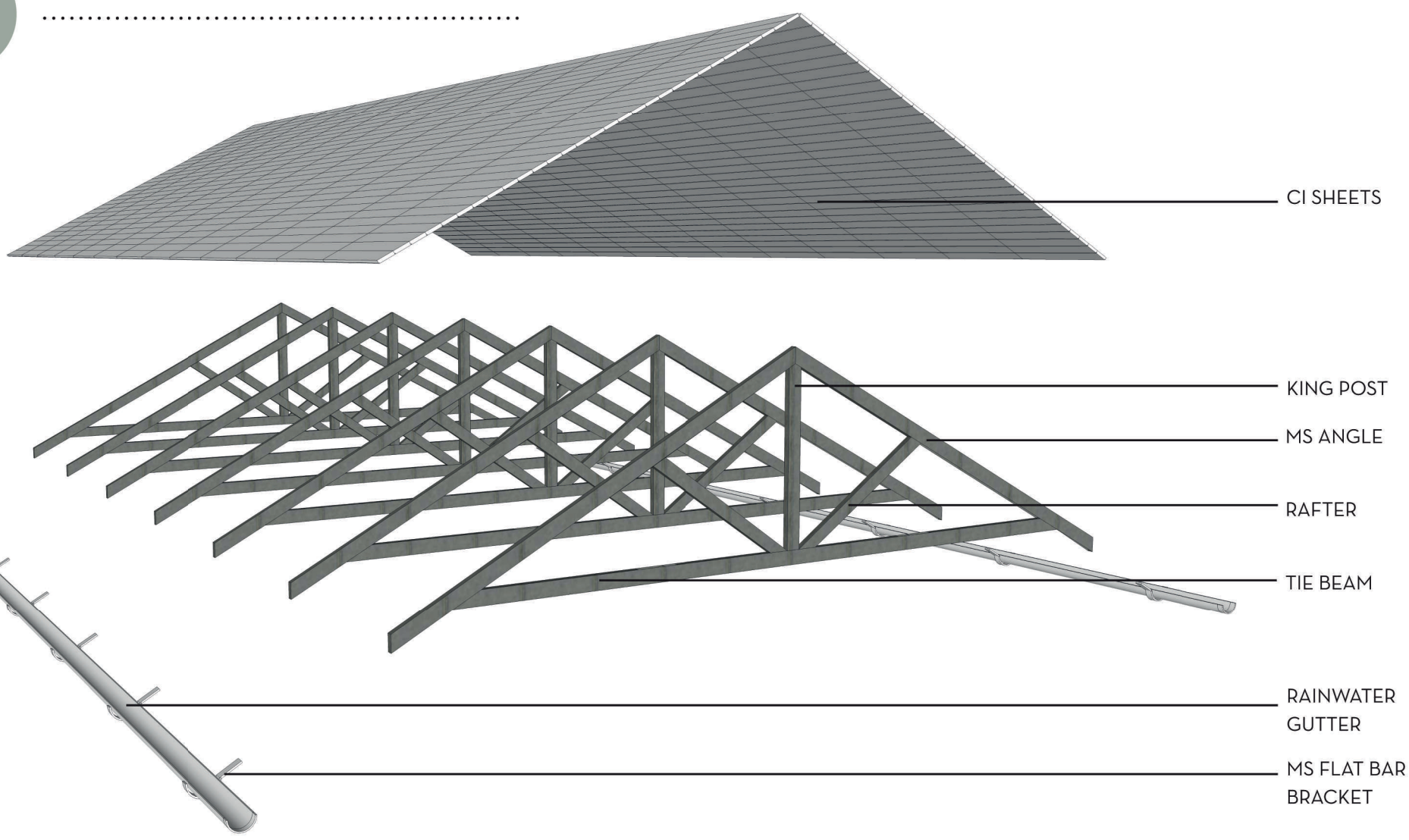


HIPPED ROOF



B

metal structure



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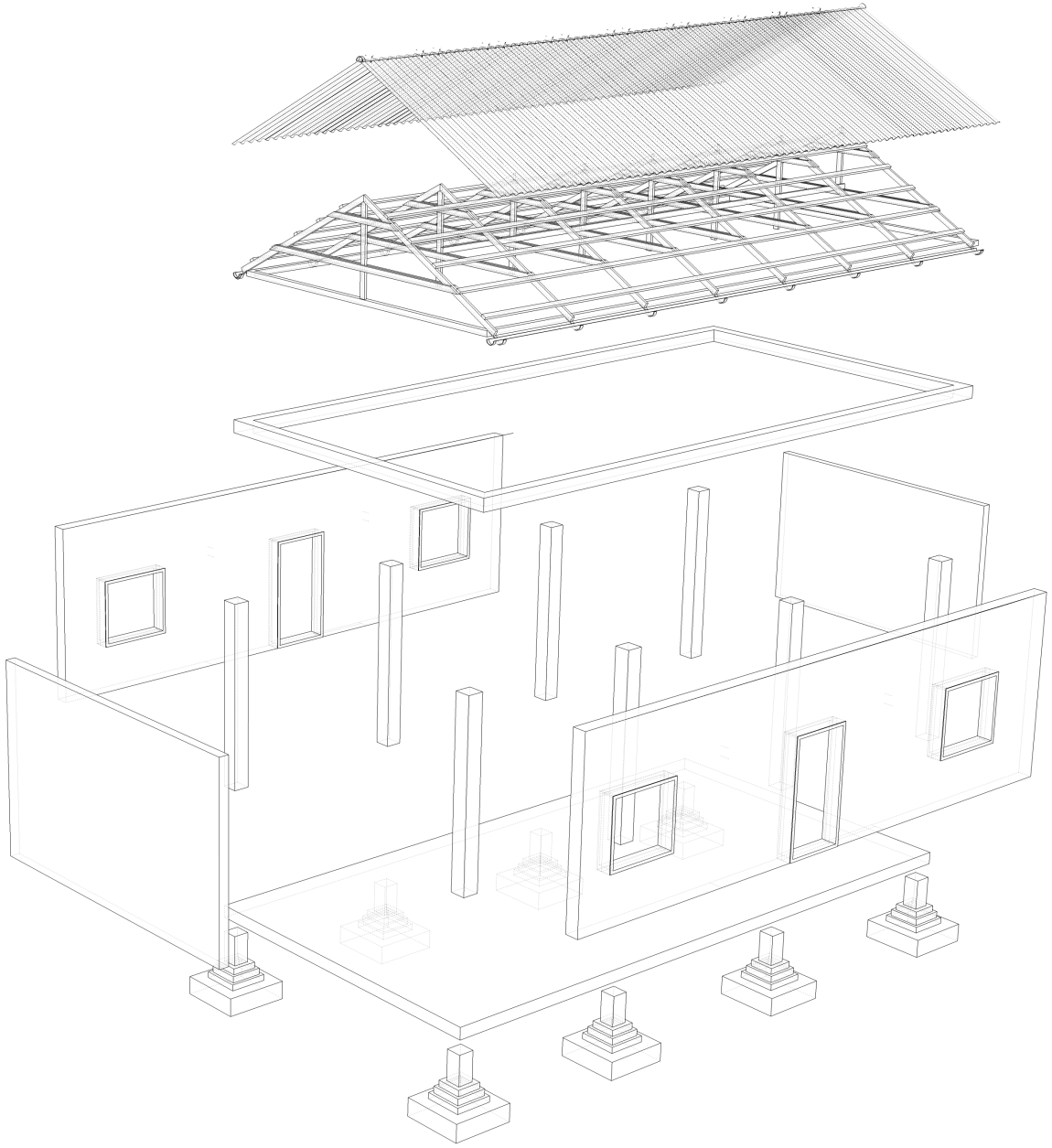
ix. Grey Building Handbook : Bengali.



দক্ষিণ এশিয়ায় দুর্যোগ সহনশীল ও নিরাপদ ভবন নির্মাণ বিধিমালার সম্ভাবনা এবং অন্তরায়

নেপাল ও বাংলাদেশ

এশিয়া প্যাসিফিক নেটওয়ার্ক ফর গ্লোবাল চেঞ্জ রিসার্চ (এপিএন)-এর অনুদানে এবং কোলাবরেটিভ রিজিওনাল রিসার্চ প্রোগ্রাম (সিআরআরপি)-এর সহযোগিতায়

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সূচীপত্র

মুখবন্ধ

"দক্ষিণ এশিয়ায় দুর্যোগ সহনশীল ও নিরাপদ ভবন নির্মাণ বিধিমালার সম্ভাবনা এবং অন্তরায়" শীর্ষক এই নির্দেশিকাটি কোলাবরেটিভ রিজিওনাল রিসার্চ প্রজেক্ট এর অধীনে এবং এশিয়া প্যাসিফিক নেটওয়ার্ক ফর গ্লোবাল চেঞ্জ নেটওয়ার্ক (এপিএন)-এর সহযোগিতায় তৈরি। এই প্রকল্পটি অস্ট্রেলিয়ার নিউক্যাসেল বিশ্ববিদ্যালয়ের নেতৃত্বে পরিচালিত। সহযোগিতায় রয়েছে বাংলাদেশের ঢাকা বিশ্ববিদ্যালয়, ব্রাক বিশ্ববিদ্যালয় এবং নেপালের ত্রিভুবন বিশ্ববিদ্যালয়।

বর্তমান পৃথিবী সবিরতভাবে নানা দুর্যোগে বাঁধাগ্রস্থ হচ্ছে। উন্নয়নশীল দেশগুলোতে এসব দুর্যোগের প্রভাব অত্যন্ত প্রকট। এসব দেশের অনিয়ন্ত্রিতভাবে গড়ে ওঠা বসতিগুলোতে বসবাসকারী নিম্নআয়ের মানুষেরা বিভিন্নভাবে ক্ষতির সম্মুখীন হয়। বিশেষকরে, কোন নিয়ম অনুসরণ না করে গড়ে উঠা ভবনগুলো অত্যন্ত ঝুঁকিপূর্ণ হয়ে থাকে। ভবন নির্মাণ এবং ভূমি ব্যবহার নীতিমালা জনগণের নিরাপত্তা এবং স্থিতিস্থাপকতা বড়াতে এবং ঝুঁকি কমাতে শক্তিশালী হাতিয়ার হিসেবে কাজ করে। উন্নয়নশীল দেশের অনেক ভবন নির্মাণ বিধিমালা উন্নত দেশ থেকে নেওয়া হয়েছে। কিন্তু, সীমিত সম্পদ এবং দুর্বল প্রশাসন ব্যবস্থার জন্য স্থানীয় আর্থসামাজিক প্রেক্ষাপটে নীতিমালার প্রয়োগ বেশ দুরূহ।

সুতরাং, নিরাপদ ভবন নির্মাণ বিধিমালা বৃহত্তর ক্ষেত্রে প্রয়োগের পথ অন্বেষণ করা যথেষ্ট প্রাসঙ্গিক প্রয়োগ কেবলমাত্র আনুষ্ঠানিক বা প্রথাগত জায়গায় সীমাবদ্ধ না রেখে অপ্রাতিষ্ঠানিক ক্ষেত্রগুলোতেও স্বেচ্ছা সম্মতির মাধ্যমে প্রসারিত করা একান্ত প্রয়োজন।

এই প্রক্রিয়ায় সহযোগিতা করার উদ্দেশ্য সাধারণ নির্দেশিকা তৈরি করা হয়েছে যা স্থানীয় প্রেক্ষাপট এবং উন্নয়নশীল দেশের আর্থ-সমাজিক প্রতিবন্ধকতার সাথে সম্পূর্ণ সামঞ্জস্যপূর্ণ বলে ধরা যায়। বিভিন্ন আর্থসামাজিক ও পারিবেশিক অবস্থার প্রেক্ষিতে নানা চিত্রকলা/নকশার মাধ্যমে অতিসহজে অনুধাবনযোগ্য করার জন্য এতে নানা ধরনের বিকল্প ব্যবস্থার সন্নিবেশ করা হয়েছে। অপ্রাতিষ্ঠানিক নির্মাণখাতই বর্তমান নির্দেশিকার প্রধান লক্ষ্য এবং গোষ্ঠী পর্যায়ে সামর্থ্য বৃদ্ধিও এর উদ্দেশ্য।

বর্তমান প্রকল্প

বর্তমান প্রকল্পটি দুর্যোগ সহনশীল দক্ষিণ এশিয়া গড়ে তোলার উদ্দেশ্যে ভবন নির্মাণের সম্ভাবনা এবং অন্তরায় অন্বেষণের উদ্দেশ্যে গৃহীত। এই প্রকল্প দুটি দেশকে কেন্দ্র করে তৈরি হয়েছে, বাংলাদেশ এবং নেপাল। দুটি দেশের সাম্প্রতিক দুর্যোগগুলো পর্যালোচনা করলে দেখা যায় যে, ভবন নির্মাণ বিধিমালা না মেনে চলার মধ্যেই মূল সমস্যা নিহিত। দুটো দেশেই ভবন নির্মাণ বিধি রয়েছে কিন্তু খুব সীমিত ক্ষেত্রেই তা মেনে চলা হয়। বিশেষকরে বিধিবহির্ভূত ক্ষেত্রগুলোতে বিধি লঙ্ঘন অধিক লক্ষ্যণীয়। এজন্য দুর্যোগ সহনশীলতা অর্জনের উদ্ধেশ্যে কিভাবে নিয়মনীতিগুলোর ব্যাপক প্রয়োগ নিশ্চিত করা যায় তা অনুধাবন করা প্রয়োজন। এ উদ্দেশ্যেই বিভিন্ন দেশের বিশ্ববিদ্যালয়ের মধ্যে সহযোগিতার মাধ্যমে সংযোগ স্থাপন করা হয়েছে।

নেপাল

নেপাল বন্ধুর ভূপ্রকৃতি, সুউচ্চ ভূমিরূপ, বৈচিত্রময় জলবায়ু এবং জটিল ভূতাত্ত্বিক বৈশিষ্ট্যের দেশ। তাছাড়া, এটি ভূগাঠনিকভাবে সক্রিয় অঞ্চলে অবস্থিত। এজন্য নেপাল ভূমিকম্প, বন্যা, ঝড়, এবং ভূমিধ্বসসহ বিভিন্ন ধরনের বিপর্যয় ঝুঁকিতে রয়েছে এবং ইতিমধ্যে অসংখ্য দুর্যোগের সম্মুখীনও হয়েছে। অপরিকল্পিত নগরায়ণ এবং অপর্যাপ্ত অবকাঠামো নির্মাণের মত মনুষ্য সৃষ্ট কর্মকান্ডের দরুন দুর্যোগ পরবর্তী ক্ষয়ক্ষতি গুরুতর হচ্ছে। ২০১৫ সালে নেপাল ভয়াবহ ভূমিকম্পের সম্মুখীন হয় যার ফলস্বরূপ বহু সংখ্যক ঘরবাড়ি ধ্বসে পড়ে এবং হতাহতের ঘটনা ঘটে।

বাংলাদেশ

বাংলাদেশ, প্রাকৃতিক দুর্যোগ এবং জলবায়ু পরিবর্তনের দরুন সবচেয়ে ঝুঁকিপূর্ণ দেশগুলোর মধ্যে অন্যতম। বাংলাদেশের জন্য প্রাথমিক হুমকি হিসেবে বিবেচিত বন্যা, ঘূর্ণিঝড়, ভূমিকম্প এবং অগ্নি দূর্ঘটনা বর্তমানে দ্রুত বর্ধমান অপরিকল্পিত নগরায়ণের কারণে উল্লেখযোগ্য সমস্যা সৃষ্টি করছে। গৃহ নির্মাণ নীতিমালার প্রতি অবহেলা এবং উদাসীনতার অর্থ হলো দুর্যোগ সংঘটনের ক্ষেত্রে কেবলমাত্র প্রাকৃতিক বিপর্যয়কে কারণ হিসেবে চিহ্নিত না করা। ২০১৩ সালে রানা প্লাজা ধ্বসের ঘটনা পূর্বোক্ত বক্তব্যকেই সমর্থন করে। এই ঘটনায় ১১০০ জনেরও বেশি পোশাক শ্রমিক নিহত হয় এবং ২৫০০ জন আহত হয়, যাদের বেশিরভাগই ছিলেন নারী।

নির্দেশিকা

এই নির্দেশিকাটি দুর্যোগপ্রবণ অঞ্চলের ভবনাদি সম্পর্কিত পরামর্শ, নির্দেশনা এবং প্রয়োজনীয় তথ্য প্রদান করে। সচরাচর এবং ঘন ঘন ঘটে থাকা বিপর্যয়গুলোকে দক্ষভাবে মোকাবিলার উদ্দেশ্যে পরিকল্পনা, স্থান নির্বাচন, নকশা প্রণয়ন এবং গৃহনির্মাণ কৌশল সম্পর্কেও প্রয়োজনীয় নির্দেশনা এতে অন্তর্ভূক্ত রয়েছে। নিরাপদ নকশা এবং নির্মাণ সম্পর্কিত নীতিমালা বাংলাদেশ এবং নেপালের ভবন মালিক এবং নির্মাণকারীদের মধ্যে জনপ্রিয় করে তোলা এর অভিষ্ট লক্ষ্য। বাড়ির অধিবাসী এবং সম্পদের সুরক্ষা নিশ্চিতের মাধ্যমে বিপর্যয়ের ঝুঁকি হ্রাসকরণ এর উদ্দেশ্যে। বর্তমান নির্দেশিকায় নির্মাণ সম্পর্কিত ধারণাগুলো সঠিকভাবে অনুধাবন এবং ব্যাখ্যার জন্য চিত্র সম্বলিত আলোচনা রয়েছে। কেননা, কেবলমাত্র বর্ণনা মাধ্যমে উক্ত ধারণাগুলোর ব্যাখ্যা প্রদান যথেষ্ট দূরূহ।

ব্যবহারবিধি

গৃহনির্মাণের ক্ষেত্রে ভিত্তি, খুঁটি, দেয়াল এবং ছাদের কোন ধরনের সমন্বয় নির্বাচন করা হবে তা নির্ধারণে ব্যবহারকারী বিচার ক্ষমতা অভিজ্ঞতা এবং পছন্দ গুরুত্বপূর্ণ ভূমিকা পালন করবে। বাড়ির নকশা প্রণয়নের ক্ষেত্রে এই নমনীয়তা ব্যবহাকারীদের অংশগ্রহণকে উৎসাহিত করবে।

এটি প্রশিক্ষণ নির্দেশিকা রূপেও ব্যবহৃত হতে পারে। প্রশিক্ষকগণ স্টেকহোল্ডারদের সাথে আলোচনার মাধ্যমে বিভিন্ন বিকল্পের মধ্য থেকে উপযুক্ত নকশা নির্বাচনে সহায়তা করতে পারেন। নিম্নোক্ত সারণীগুলো এই প্রক্রিয়াকে সহায়তা করার উদ্দেশ্যে প্রণীত।

নির্মাণ ধাপ

০১ পরিকল্পনা

গৃহ নির্মাণের পূর্বে কোন স্থানের উপযুক্ততা এবং তার পরিবেশ সম্বন্ধে নিশ্চিত ধারণা গ্রহণ আবশ্যক।

ভূপ্রকৃতি

উচ্চতা, ঢাল, বন্ধুরতা, জল নিষ্কাশন, মাটির প্রাকৃতি

অন্ত-মৃত্তিকার প্রকৃতি

নিষ্কাশন নালী, জলপথ, জলাভূমি, তট রেখা, জলপ্রবাহ

অভিগম্যতা

রাস্তার সাথে যোগাযোগ এবং ভূমির স্থিতিবস্থা সম্বন্ধীয় বিষয়াবলী, যোগাযোগব্যবস্থা এবং উদ্বাসন পথ

আকৃতি

গৃহনির্মাণের ক্ষেত্রে সাধারণ প্রতিসম আকৃতির গৃহ পীড়ন বলকে হ্রাস করে। এক্ষেত্রে বর্গাকৃতি এবং আয়তাকৃতি গৃহকে প্রাধান্য দেয়া হয়।

০২ ভিত্তি

বাড়ির ভিত্তি বা ফাউন্ডেশনের মূল কাজ হল বাড়ির কাঠামোর ভার, অস্থায়ী ভার এবং বাহ্যিক চাপকে সুষমভাবে বণ্টনের মাধ্যমে বাড়িকে নিরাপদ রাখা

ভিত্তি তৈরির উদ্দেশ্যে হল-

১। সহ্যসীমা অনুযায়ী ভূমির উপর কোন বসতিকে ধরে রাখা

২। পরিবর্তনের মধ্য দিয়ে যাওয়ার মত পর্যাপ্ত শক্তি এবং দৃঢ়তা থাকা

৩। স্থিতিশীল এবং টেকসই হওয়া

০৩

মূল অংশ

কাঠামোর ভার বহন, প্রতিকূল পরিবেশের হাত থেকে রক্ষা করা, বাতাস ও আলো চলাচলের উপযুক্ত করে এই অংশটি তৈরি করা প্রয়োজন।

প্রকার ১
কংক্রিটের কাঠামো এবং ইটের দেয়াল

প্রকার ২
ভার সহনশীল ইটের দেয়াল

প্রকার ৩
কাঠের কাঠামো এবং মাটির ব্লক।

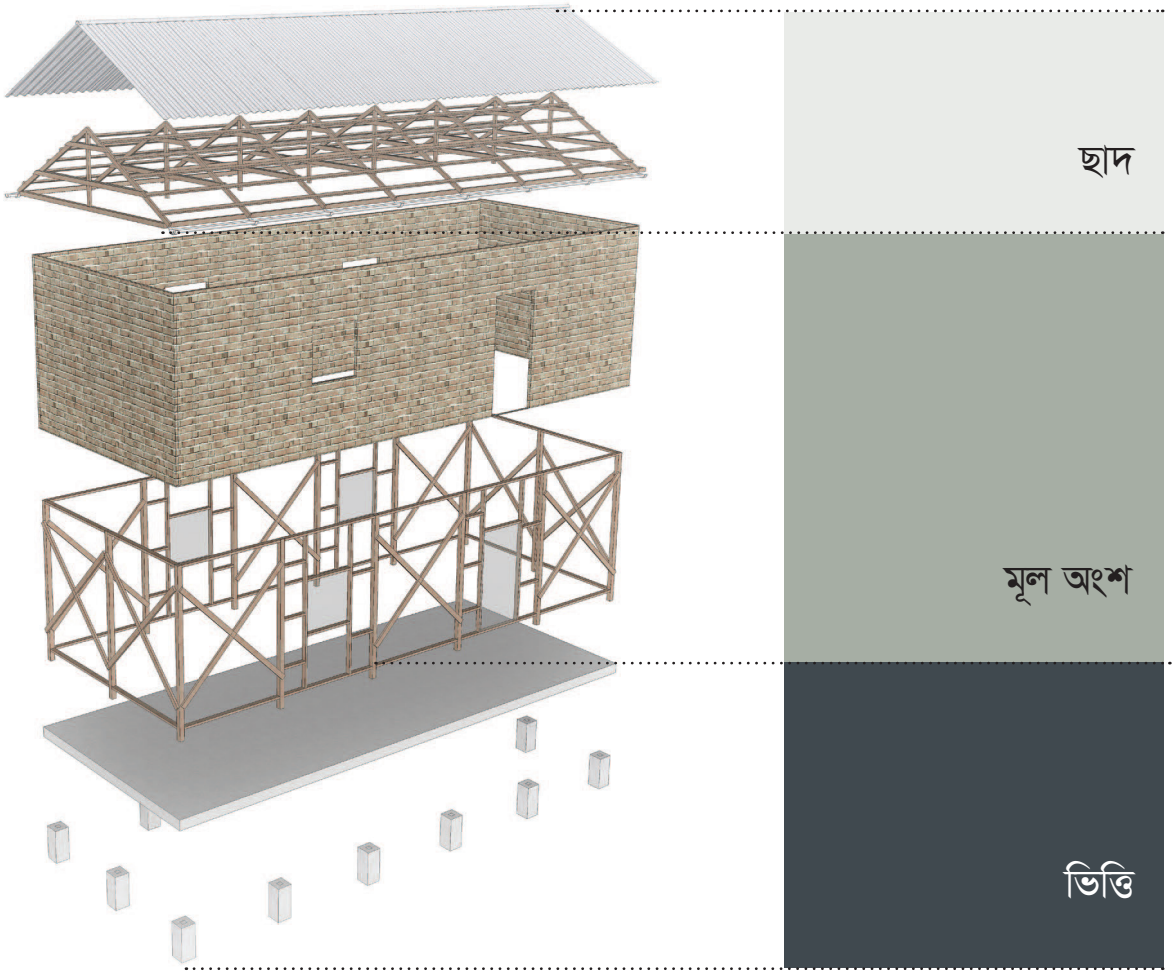
০৪

ছাদ

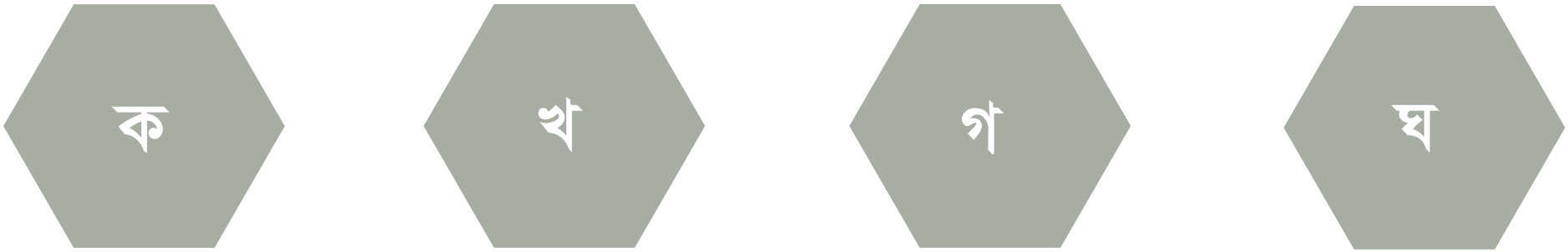
ছাদ নির্মানের ক্ষেত্রে ২ ধরনের পদ্ধতি অনুসরণ করা যেতে পারে। ঢেউখেলানো শিট বা টাইলস দিয়ে তৈরী হেলানো বা ঢালু ছাদ। অথবা, রিইনফোসর্ড কংক্রিট স্ল্যাব দ্বারা তৈরি সমতল ছাদ।

প্রকার ১
রিইনফোর্সড কংক্রিট

প্রকার ২
কাঠের কাঠামো এবং সি আই শিট/টাইলস



নির্মাণশৈলির বিকল্প



ভিত্তি

ধারাবাহিক

ফুটিং

খুঁটি

আর সি খুঁটি

কাঠ

দেয়াল

ইট

কংক্রিট ব্লক

মাটির ব্লক

হালকা ওজনের বস্তু

বাঁশ

ছাদ

আর সি স্ল্যাব

কাঠের ফ্রেম এবং

সি আই শিট/টাইলস

বৃষ্টির পানি নিষ্কাশনের নালা

০১–পরিকল্পনা

বাতাসের চাপ বাড়ির উপর কতটা প্রভাব ফেলবে তা নির্ভর করে বাড়ির গঠন, কতটুকু অংশের উপর বাতাস সরাসরি আঘাত করছে, বাড়ি নির্মাণের গুণগত মান মৌলিক নকশাসমূহের মধ্যে সমন্বয় কতটা সুসংহত তার উপর।

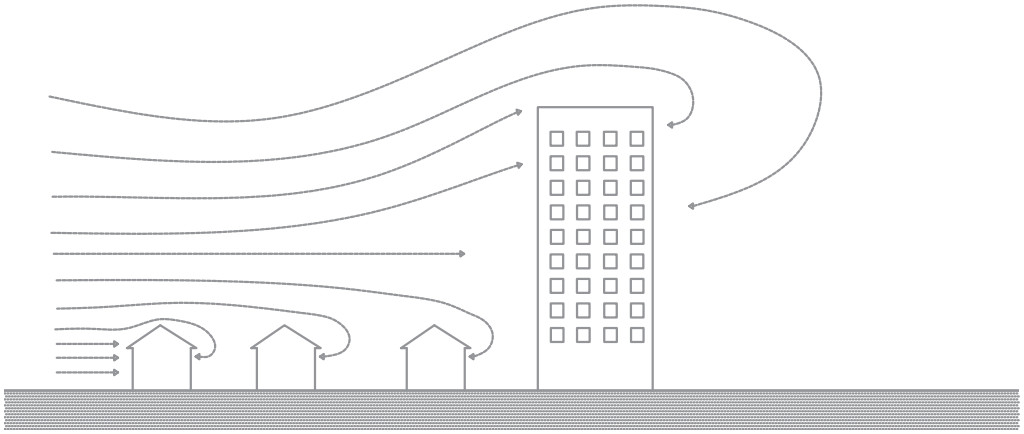
উঁচু দালানগুলোর থেকে অপেক্ষাকৃত নিচু দালানগুলোকে ঘূর্ণিবায়ু থেকে কিছুটা সুরক্ষা প্রদান করে।

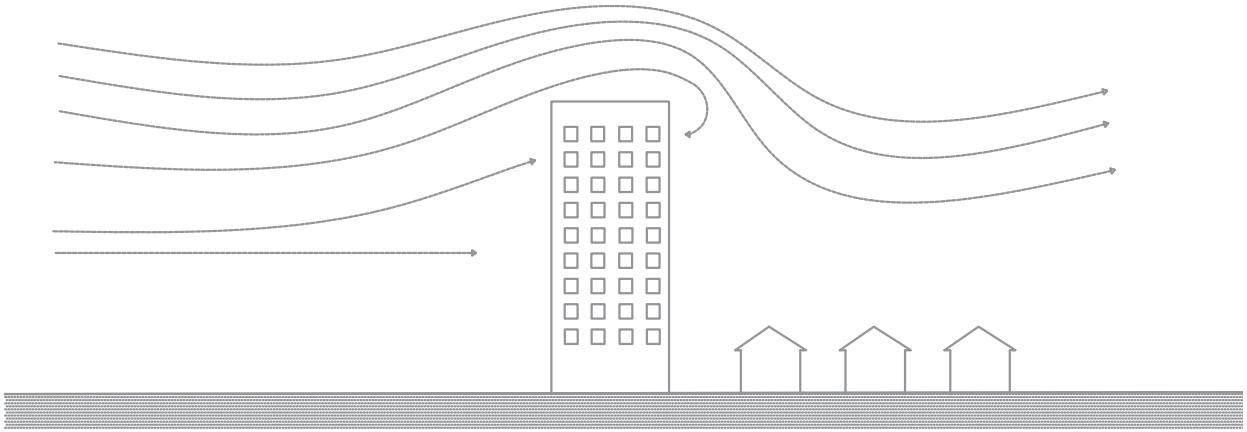
ঘূর্ণিঝড় প্রবণ অঞ্চলে গৃহ নির্মাণের জন্য স্থান বাছাইয়ের ক্ষেত্রে উঁচু দালানকে বাতাসের প্রতিবন্ধক রূপে ব্যবহার করা যেতে পারে।

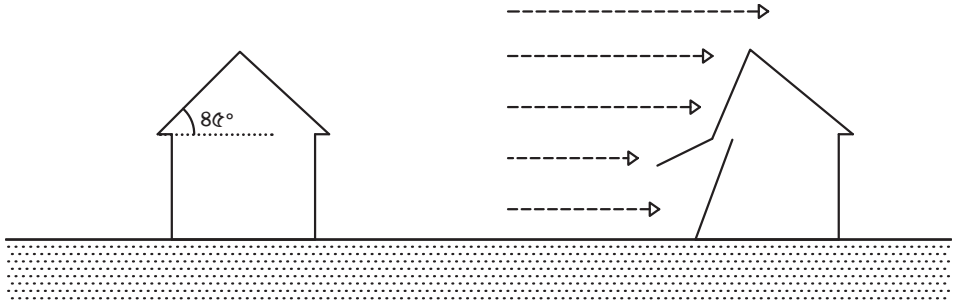
ঘূর্ণিবায়ুর সৃষ্টি, স্থানীয় বায়ুর প্রত্যাগমন, দমকা বাতাস এবং বায়ুহীন অনুবাত অঞ্চল সৃষ্টি হওয়ার পেছনে অন্যতম কারণ হিসেবে উঁচু দালানকে ধরা যেতে পারে।

উঁচু দালানের আড়ালে থাকা স্থানগুলো বায়ুসৃষ্টি বিপর্যয়গুলো থেকে কিছুটা সুরক্ষিত থাকে। খাড়া প্রান্ত এবং খাড়া উপত্যকা অঞ্চল যেসব সমুদ্রের দিকে উন্মুক্ত সেসব অঞ্চলগুলো এড়িয়ে যাওয়া উচিত।

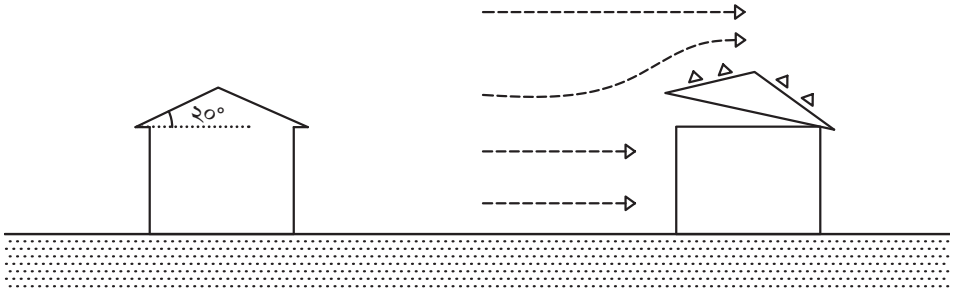
বসতি নির্মাণের ক্ষেত্রে রৈখিক প্যাটার্ন পরিহার করা প্রয়োজন। কেননা উন্মুক্ত, সোজা ও সমান্তরাল পথে চলাচলের সময় বায়ুর গতি অত্যাধিক বৃদ্ধি পায় এবং "টানেল প্রভাব" সৃষ্টি করে।



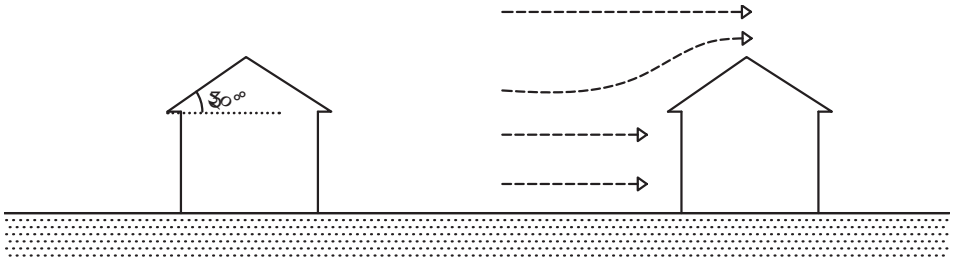




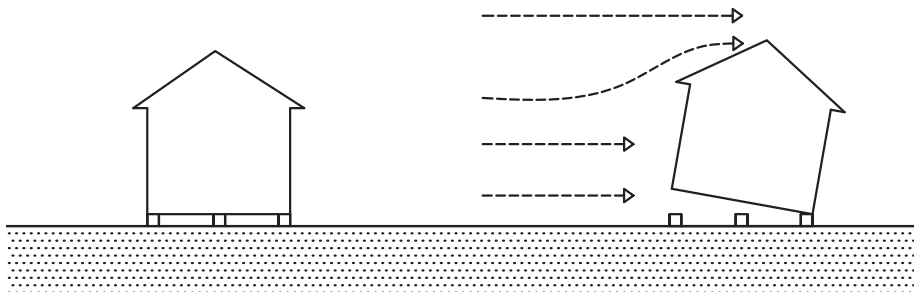
অত্যাধিক খাড়া ঢালের ছাদ বাতাসের চাপের সম্মুখীন হয় তুলনামূলক বেশি। ফলে, ছাদ উড়ে যাবার সম্ভাবনা থাকে।



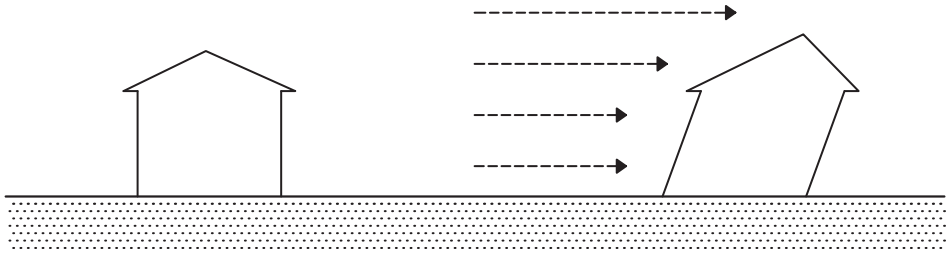
অত্যাধিক হেলানো ঢাল হলে, বাড়ির ছাদকে অধিক সাকশন বা শোষাণের সম্মুখীন হতে হয়। এতে করেও ছাদ উড়ে যাবার সম্ভাবনা তৈরি হয়।



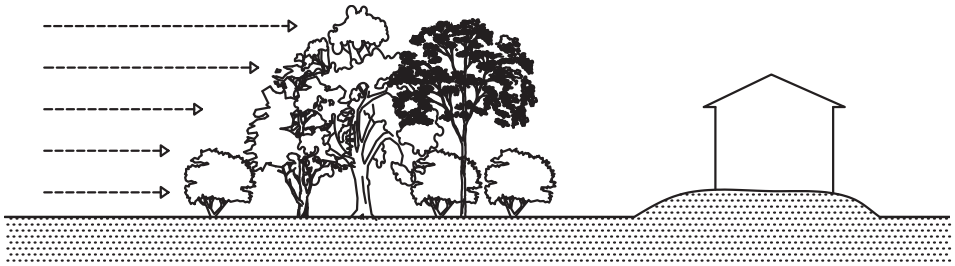
বাড়ির ছাদের ঢাল ৩০° হলে সেটি সামান্য বাতাসের চাপের সম্মুখীন হয়।



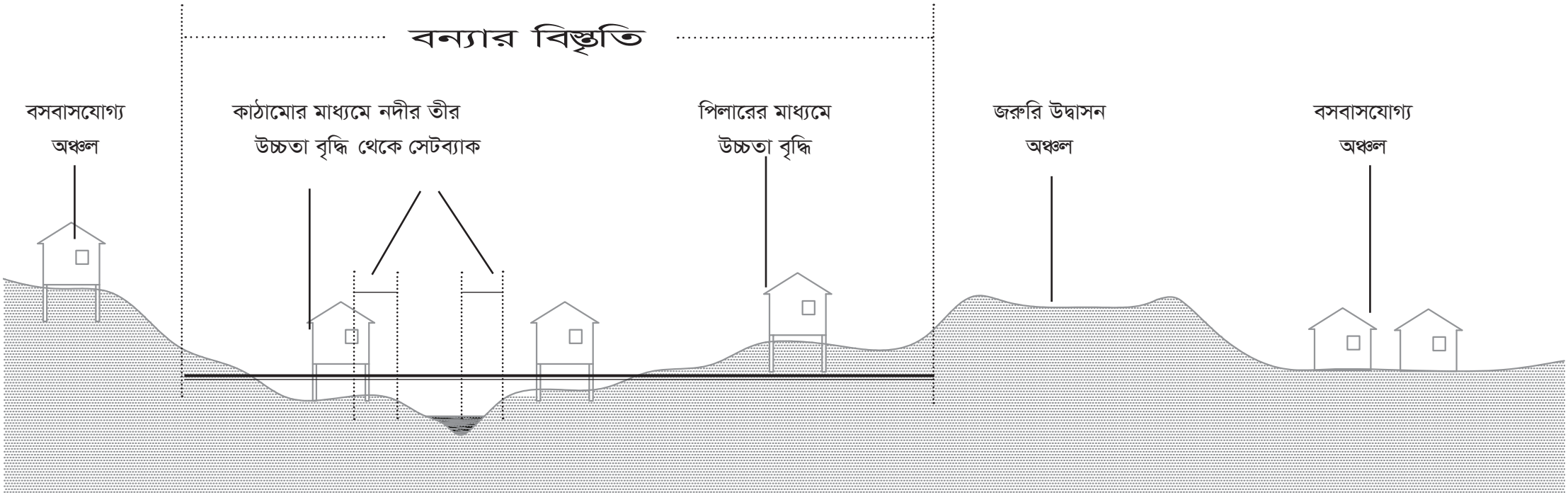
মজবুতভাবে বাড়ির কাঠামো তৈরি হলেও, যদি তা তার ভিত্তির সাথে শক্তভাবে আটকানো না থাকে, তবে বাড়িটি সহজেই উল্টে যেতে পারে।



মজবুতভাবে বাড়ির কাঠামো তৈরি হলেও, যদি তা তার ভিত্তির সাথে শক্তভাবে আটকানো না থাকে, তবে বাড়িটি সহজেই উল্টে যেতে পারে।



বাড়ি হতে কিছু দূরত্বে অবস্থিত গাছপালার আচ্ছাদন ঝড়ের সময় ঢাল হিসেবে কাজ করে বাড়িকে সুরক্ষিত রাখে। বায়ুর প্রতিবন্ধকস্বরূপ গাছগুলোর সর্বোচ্চ উচ্চতার সমান দূরত্বে বাড়িটি অবস্থিত হবে। এছাড়াও, উঁচু ভিত্তির উপর তৈরি করা বাড়ি বন্যার সময় বাড়িটিকে বন্যামুক্ত রাখবে।



গৃহ নির্মাণের জন্য স্থান নির্বাচনের ক্ষেত্রে ভূমির স্থায়িত্ব এবং একই সাথে ঝড়ো বাতাস ও বন্যার হাত থেকে গৃহকে নিরাপদ রাখার মত বিষয়গুলো বিবেচনায় আনতে হয়। অন্য যেকোন জটিল জ্যামিতিক আকৃতি অপেক্ষা সাধারণ আয়তাকৃতির ভবন ভূমিকম্পের সময় অপোকৃত নিরাপদ। ভূ-আলোড়নের দরুন সৃষ্টি বল লম্বা ও সরু আয়তাকৃতির বকের উপর সুস্পষ্টভাবে লক্ষ্যণীয়।

এজন্য ভবনের দৈর্ঘ্য তার প্রস্থের ৩ গুণের মধ্যে সীমাবদ্ধ থাকা বাঞ্ছনীয়। তবে, দৈর্ঘ্য এর চেয়ে বাড়াতে হলে দুটো আলাদা বক তৈরি করা উচিত।

প্রতিসাম্য এবং ধারাবাহিকতা অর্জনের জন্য বড় দালানকে কতগুলো বকে বিভক্ত করা প্রয়োজন।

জলোচ্ছ্বাস এবং উপকূলমুখী সমুদ্রের ঢেউ থেকে জনবসতি রক্ষার্থে বাঁধ নির্মাণ করতে হবে। সমুদ্রাভিমুখী পার্শ্বে ঢেউয়ের শক্তি কমানোর জন্য পাথর ব্যবহার করতে হবে। অপর পার্শ্বে গভীর মূলবিশিষ্ট বৃক্ষরোপণ করতে হবে যাতে মাটিকে একত্রে ধরে রাখা যায় এবং কম হয়।

নদীর মোহনার মাধ্যমে ঘূর্ণিঝড়ের প্রভাব স্থলভাগে বন্যার সৃষ্টি করতে পারে। এজন্য, বন্যা-নিরোধক, জরুরি উদ্বাসন পথ এবং আশ্রয় অঞ্চল তৈরি করা বিশেষ প্রয়োজন।

০২ – ভিত্তি

ক

ধারাবাহিক

মাটি ও সিমেন্টের মিশ্রণের মাধ্যমে মাটির ভিত্তি তৈরি করা যেতে পারে। সিমেন্টকে ন্যূনতম ৩ সপ্তাহ পানি দিয়ে কিওরিং করতে হবে।

বিকল্পঃ স্থিতিশীল এবং দৃঢ় মাটির ভিত্তি ব্যবহার করা।

খ

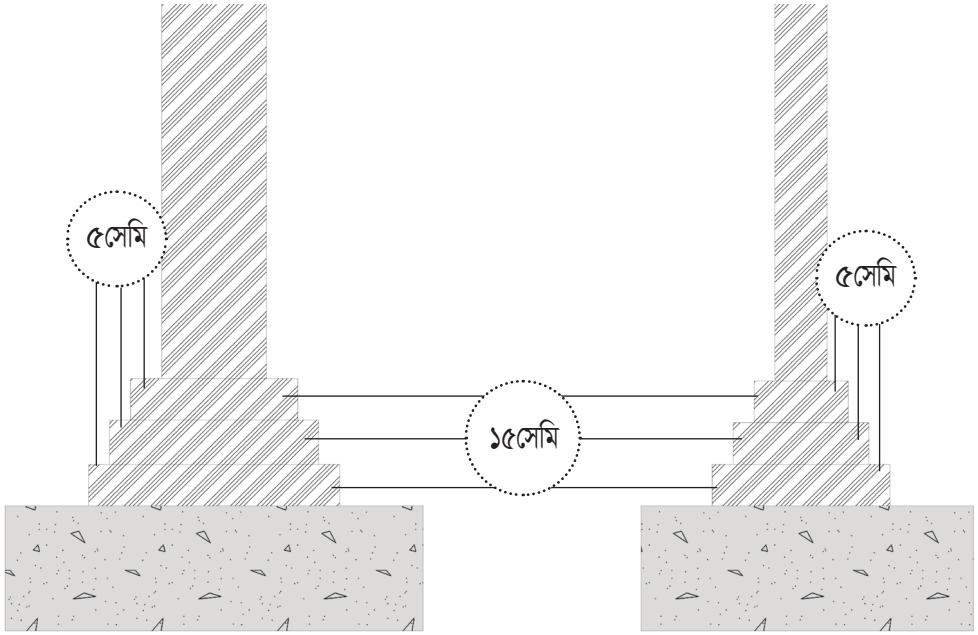
ফুটিং

কলাম ফুটিং

- কলামের নিচে স্বতন্ত্র ফুটিং ব্যবহার করা
- মাটির উপরে ভার সমভাবে বণ্টন করা
- বর্গ, আয়ত অথবা গোলাকৃতি
- মাটির ভার বহন মতার উপর ভিত্তি করে ইট, পাথর রিইনফোসর্ড যেকোন ফুটিং ব্যবহার করা যেতে পারে।

দেয়ালের ফুটিং এবং আর সি ফুটিং

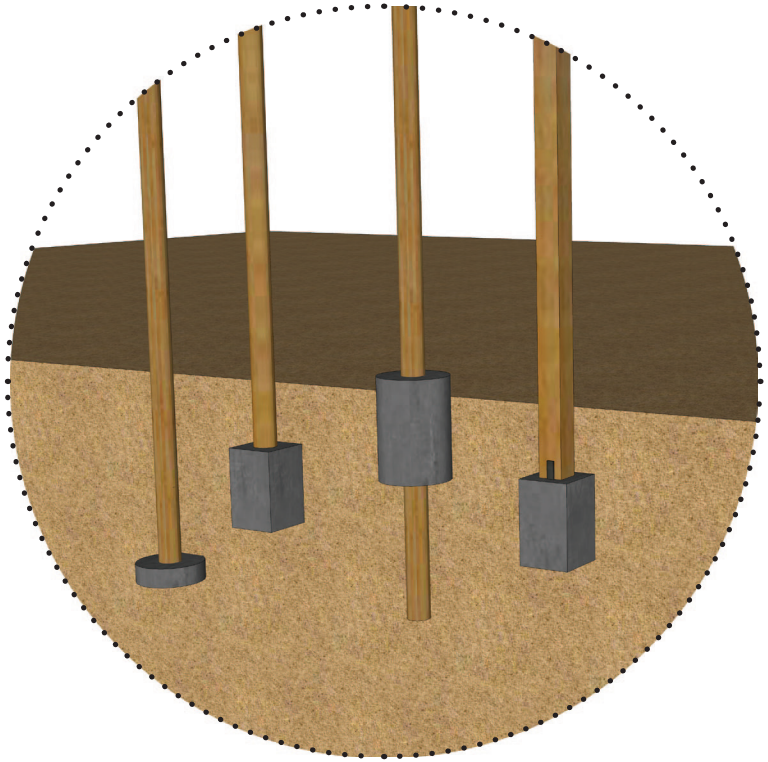
- কয়েক স্তরের ইটের সারি, উপরের তুলনায় নিচের স্তরের পুরুত্ব দ্বিগুণ হবে।
- চওড়া ভিতের জন্য ৫ সেমি অফসেট ব্যবহার, ইটের দেয়ালগুলো এক ইটের সমান চওড়া হবে। কিন্তু, বিশেষ ক্ষেত্রে নিচের দিকের সারিগুলো দুই ইটের সমান চওড়া হতে পারে।
- লিন বা পাতলা কংক্রিটের ভবন সর্বনিম্ন ১৫ সেমি হয়। প্রতি পাশের প্রোজেকশন ১০-১৫ সেমি, বেস ওয়ালের বাইরে বেডের গভীরতা প্রোজেকশন এর চেয়ে কম হওয়া যাবে না।
- ওয়াল ফুটিং শুরু করার ক্ষেত্রে কংক্রিটের বেড সমতল পৃষ্ঠ নিশ্চিত করে। খননকার্য এবং ব্রিজ তৈরিতে নরম মাটিতে সৃষ্ট অসমাঞ্জস্যের প্রতিকার করে।
- যখন লোড/ভার অনেক বেশি থাকে এবং মাটির ভার বহন ক্ষমতা কম থাকে তখন আর সি ফুটিং ব্যবহার করা হয়। অন্যথায় বিশালাকার কাঠামো তৈরীয় আবশ্যকতা দেখা দেয় যা অর্থনৈতিকভাবে মোটেই সাশ্রয়ী নয়।
- ৭-৮ সেমি পাতলা কংক্রিটের বেড ব্যবহার করতে হবে আর সি ফুটিংয়ের নিচে।



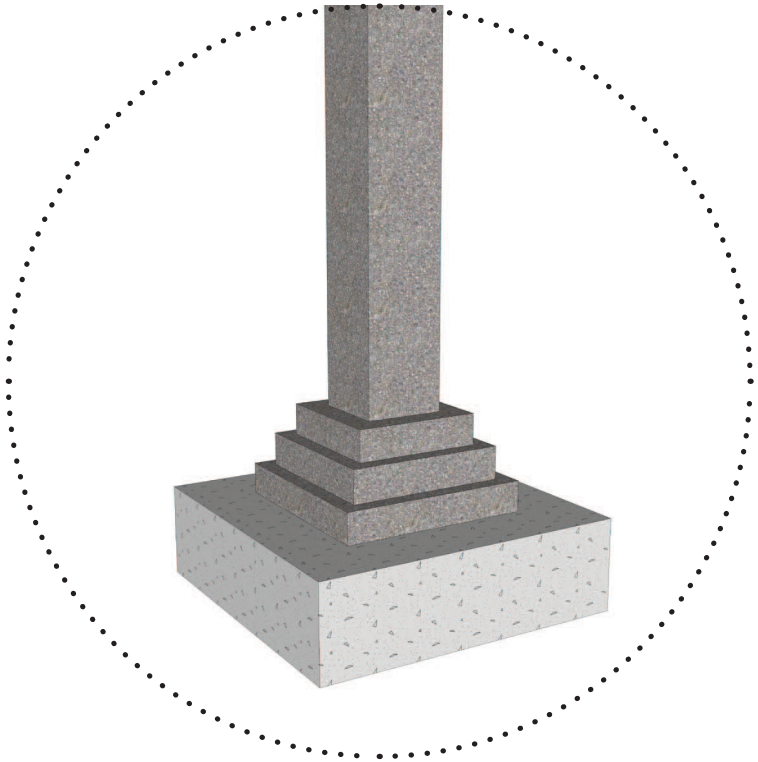
দেয়ালের প্রস্থ ২৫ সেমি

দেয়ালের প্রস্থ ১২.৫ সেমি

ফুটিংয়ের প্রকারভেদ



কাঠ/বাঁশের খুঁটি



কংক্রিট/ইটের খুঁটি

০৩-খুটি

গ

আর সি কংক্রিট খুঁটি

১. কংক্রিটের মিশ্রণের অনুপাত সাধারণত সিমেন্ট, বালু এবং খোয়ার জন্য ১:২:৩ অথবা ১:২:৪ রাখা হয়।

২. রিইনফোর্সমেন্ট হিসেবে নিম্নোক্ত যেকোনটি ব্যবহার করা যেতে পারে-

(ক) হালকা ও মাঝারি শক্তির প্রসারণযোগ্য স্টিলের বার

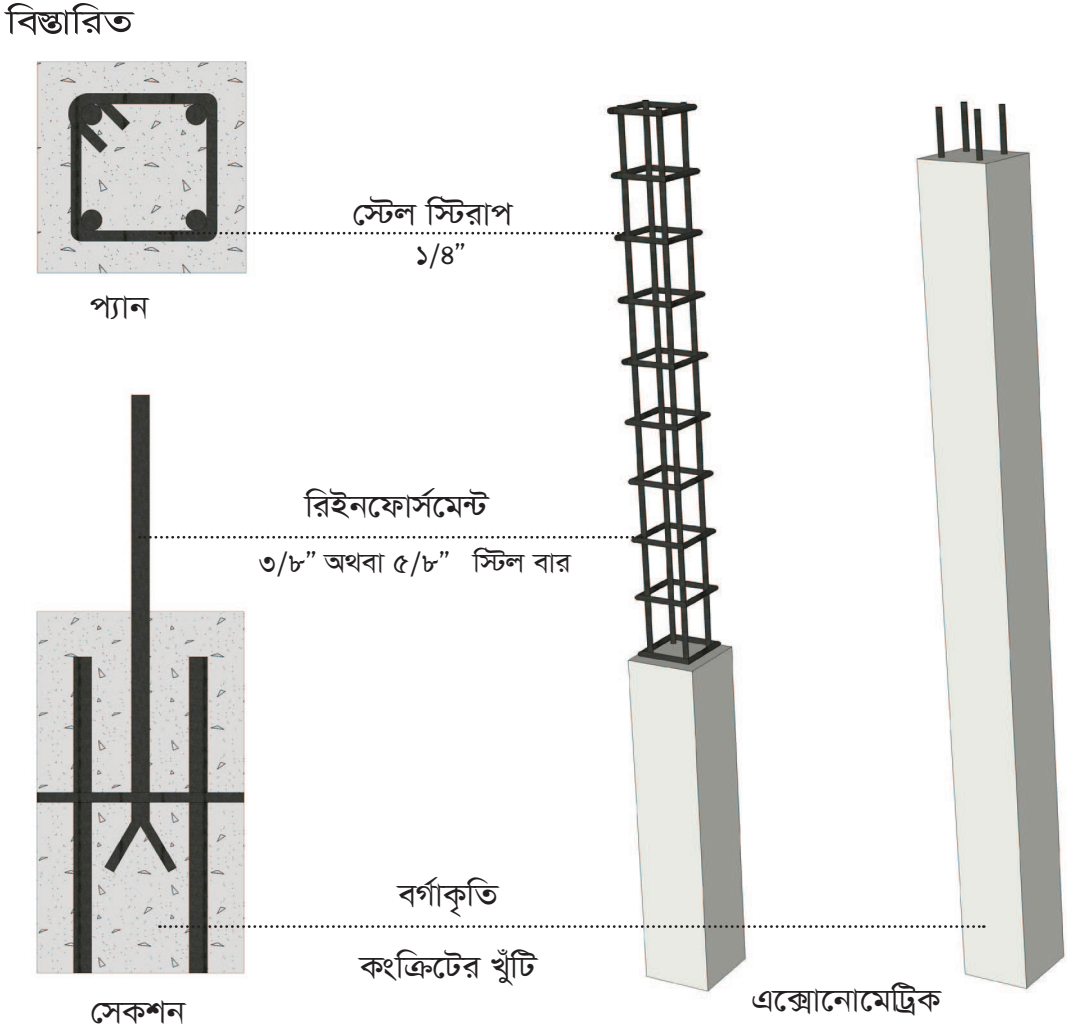
(খ) অধিক শক্তিশালী পরিবর্তিত স্টিল বার

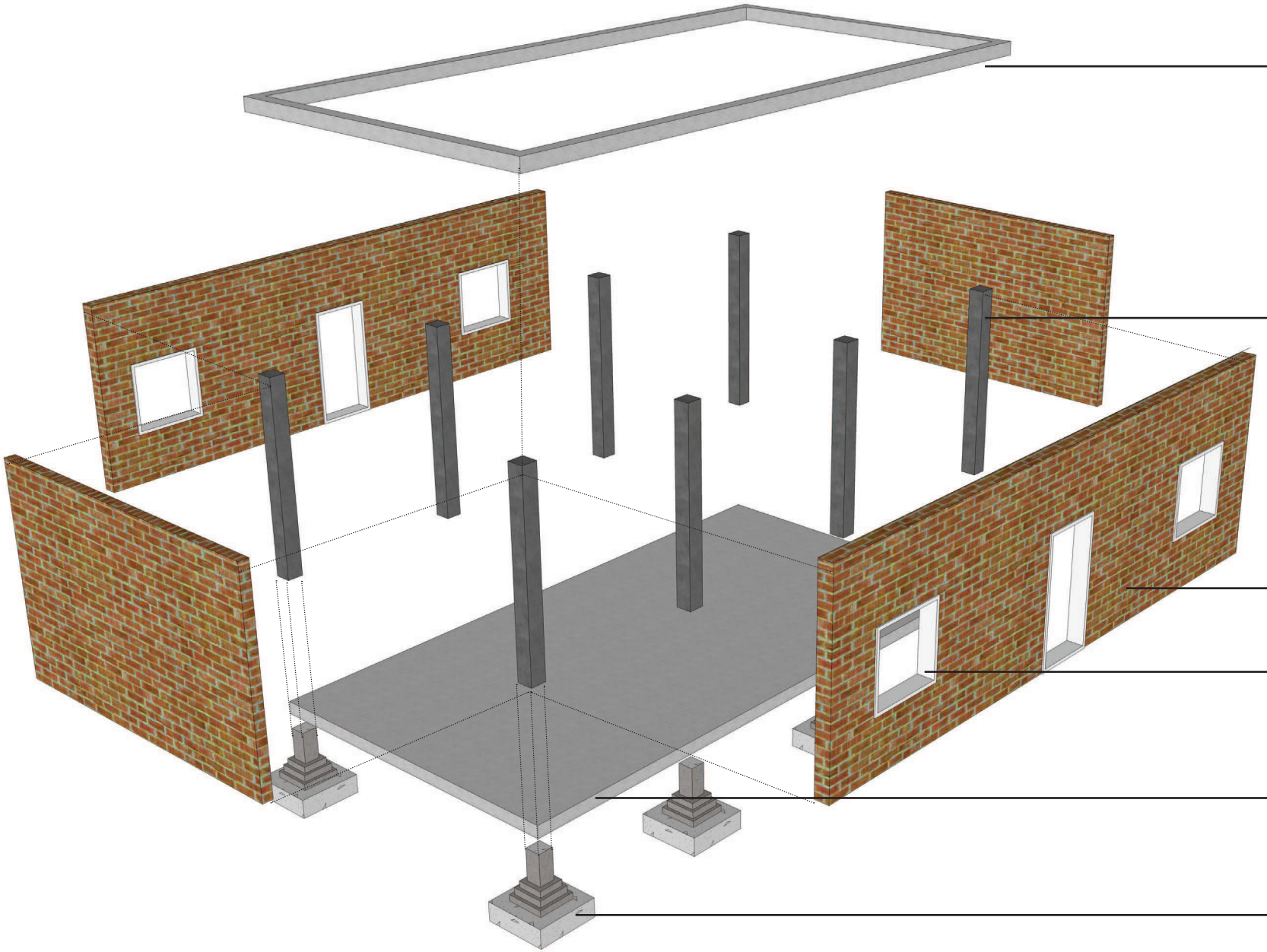
৩. সকল রিইনফোর্সমেন্টকে মরিচা এবং রং, তেল, কর্দম অথবা অন্য যেকোন পদার্থ যা কংক্রিটের বন্ধনকে নষ্ট করে দেয় বা হ্রাস করে তা থেকে মুক্ত রাখতে হবে। চার স্টেলবিশিষ্ট ১৫ মিমি ব্যাসের রি-বার ব্যবহার করতে হবে যা ৬ মিলি ব্যাসের স্টিরাপের সাথে যুক্ত থাকবে। ৪-১০ ইঞ্চি ফাঁকা রাখতে হবে।

৪. বর্গাকৃতির কলামের মাপ ন্যূনতম ২০×২০ সেমি হতে হবে এবং একটি কলাম হতে অপর কলামের দূরত্ব ৩ মিটারের বেশি রাখা যাবে না।

৫. দেয়ালকে ধরে রাখার জন্য এবং ছাদের ভিত্তি হিসেবে কংক্রিটের ফ্রেম ব্যবহার করতে হবে। অথবা, ছাদের স্ল্যাবও একই কাজে ব্যবহার করা যায়।

৫. চারপাশের কংক্রিট রডের ফ্রেমকে বেষ্টন করে উপরে উঠবে, অগ্রভাগে গিয়ে মিলিত হবে।




কংক্রিট ফ্রেম
আর সি কংক্রিট খুঁটি
ইটের দেয়াল
জানালা
কংক্রিট স্যাব
কংক্রিট স্যাব

০৪- দেয়াল

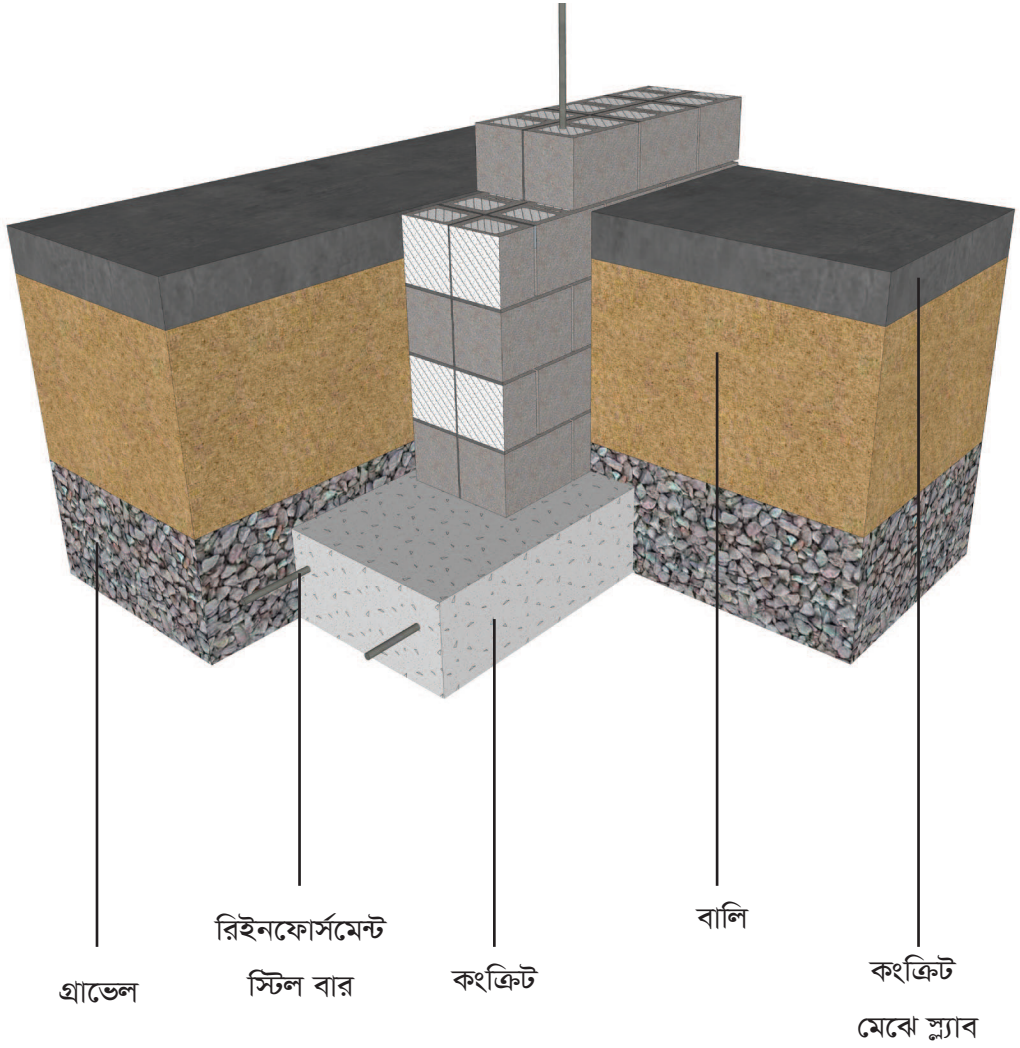
ক

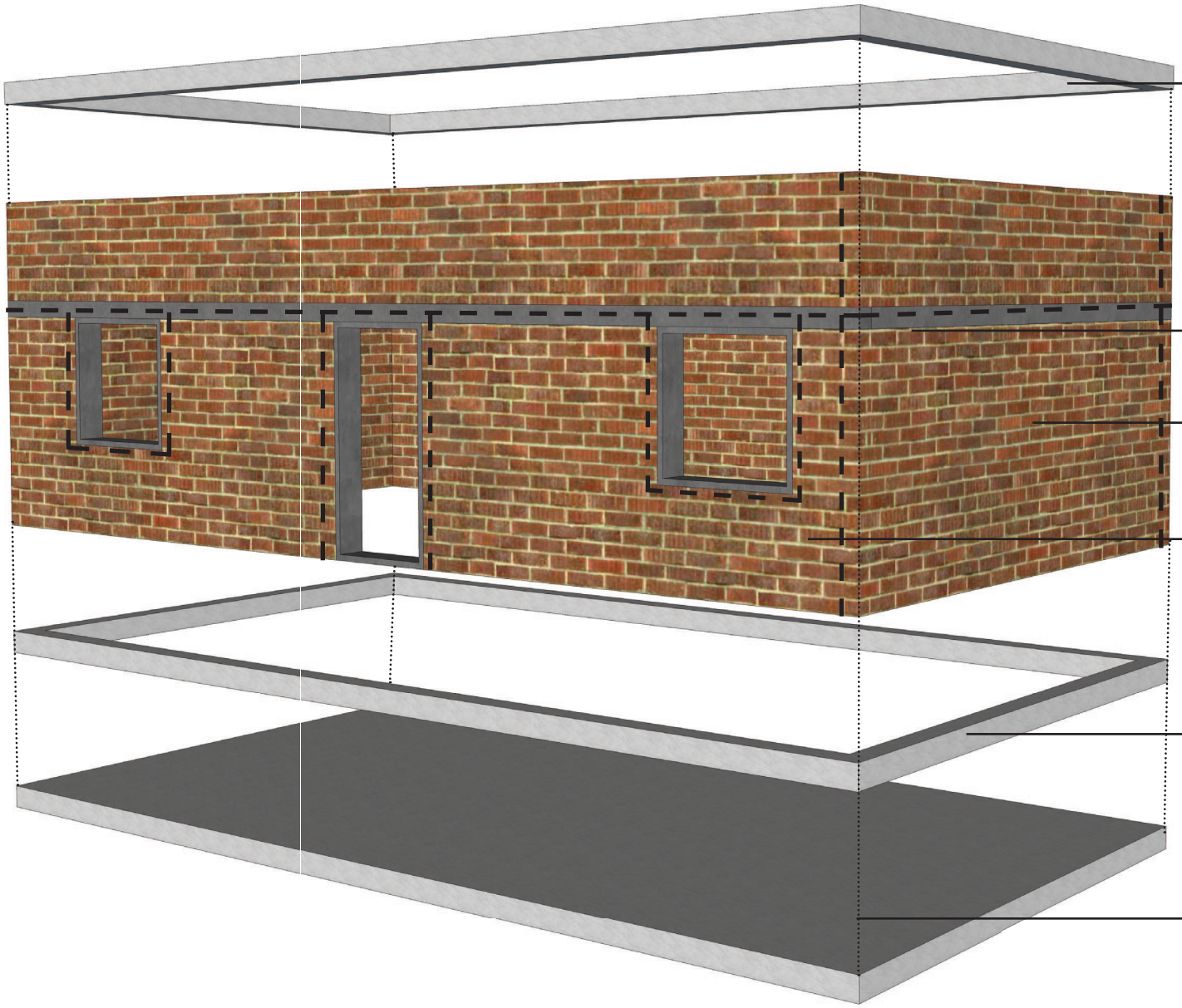
ভার বহনকারী দেয়াল

হালকা স্টিল বার, হুপ লোহা, সম্প্রসারিত জাল অথবা বারের মাধ্যমে মজবুত গাঁথনির কাজ করা সম্ভব। যে কোন ধরনের চাপ যা প্রসারণ, সংকোচন বা বিভক্তির সৃষ্টির করে তা প্রতিহত করতে এই মজবুত গাঁথনি সাহায্য করে।

আড়াআড়িভাবে প্রবাহিত শক্তিকেও প্রতিহত করার সামর্থ্য রাখেঃ

- ভূআলোড়ন এবং ঘূর্ণিঝড় প্রবণ অঞ্চল
- কোন মিলনস্থান বা ফাঁকা জায়গা ব্যতীত লম্বা দেয়ালগুলোর জন্য।
- রিইনফোর্সড সেকশন তৈরি করার ক্ষেত্রে ফাঁপা দেয়ালের জন্য <১.২ মিটার ব্যবধান এবং নিরেট দেয়ালের জন্য ২.০ মিটার ব্যবধান রাখতে হবে।
- রিইনফোর্সমেন্টের চারিদিকে ১৫.২৫ সেমি আবরণ প্রয়োজন যাতে য়কার্য প্রতিরোধ করা যায়।
- রিইনফোর্সড ইটের কলাম এবং মেঝের স্যাব ও প্রয়োজন।
- দেয়ালের জন্য কংক্রিটের ধারাবাহিক ফুটিং এবং প্রত্যেক কোণায়, দুটি দেয়ালের মিলনস্থানে, দরজায় প্রত্যেক কোণায়, বড় ফাঁকা জায়গায় এবং মাঝামাঝি জায়গায় <১.২ মিটার ব্যবধানে রিইনফোর্সড বার ব্যবহার করতে হবে।



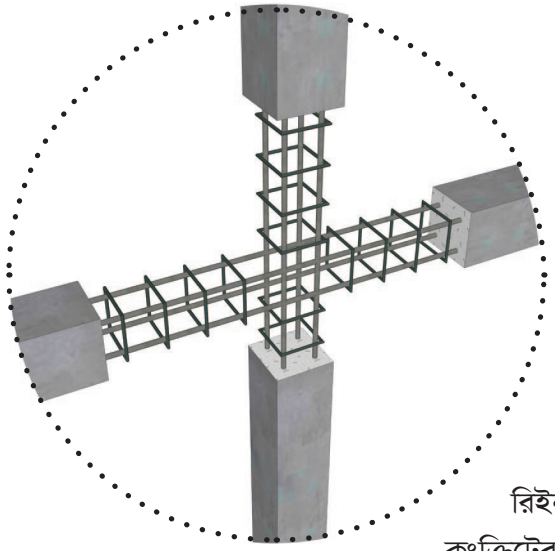

উপরিস্থ
কংক্রিট
ফ্রেম
কংক্রিটের চৌকাঠ
ভার বহনকারী দেয়াল
প্রত্যেক কোণা এবং
উন্মুক্ত জায়গার
চারপাশে
রিইনফোর্সমেন্ট
কংক্রিট ব্যান্ড/টাই বিম
কংক্রিটের মেঝের স্যাব

খ

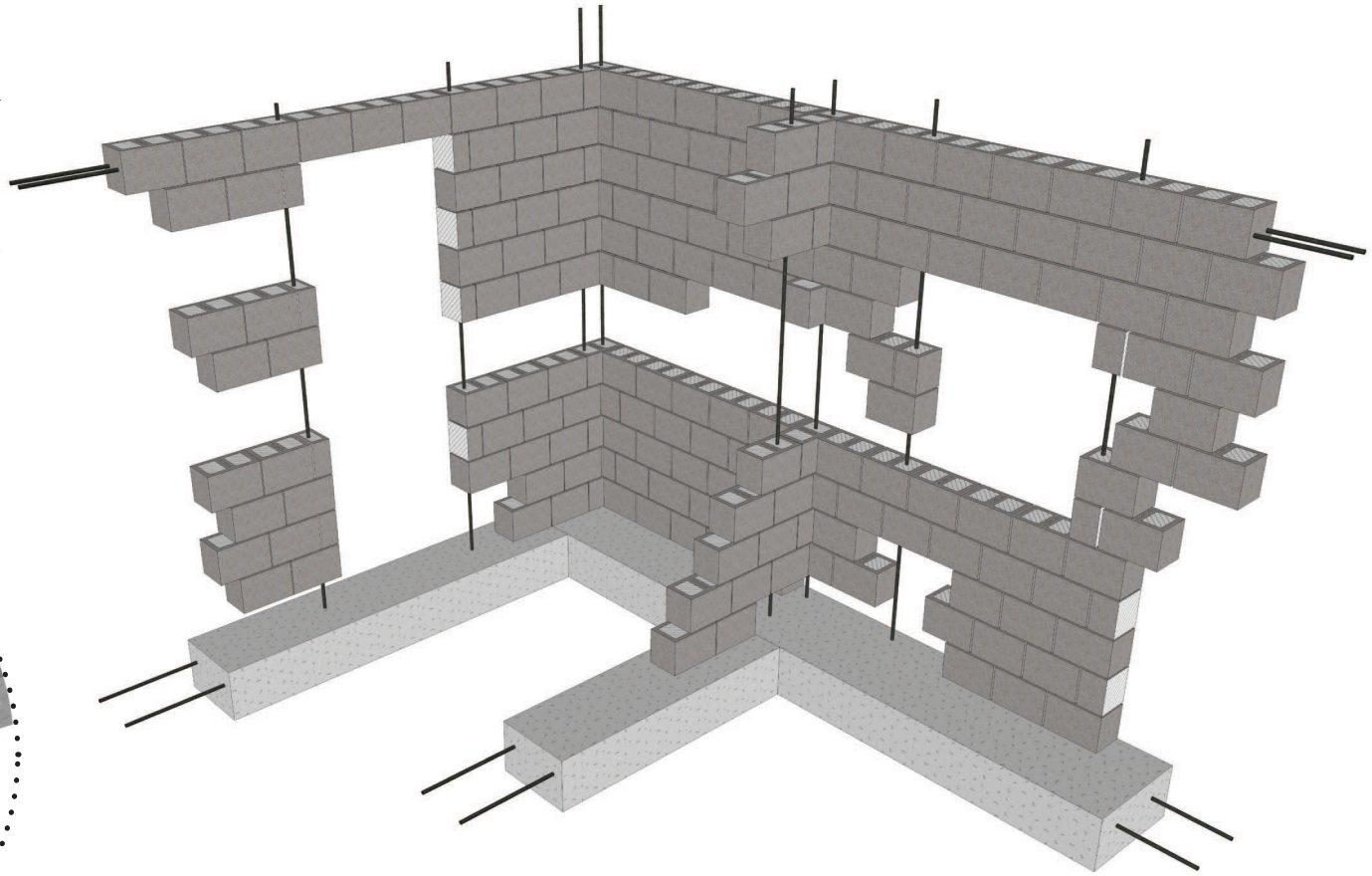
মজবুত গাঁথনি

দেয়ালের প্রতিটি কোণায়, দুই দেয়ালের মিলনস্থানে এবং দরজা-জানালার পার্শ্বে শক্তিবৃদ্ধির ব্যবস্থা করতে হবে।

উলম্ব এবং আনুভূমিকভাবে শক্তিবৃদ্ধির মাধ্যমে ভবনকে ভূমিকম্প মোকাবেলা করার মত মজবুত করা সম্ভব।



বিস্তারিত
রিইনফোর্সমেন্টসহ
কংক্রিটের সন্ধি স্থান বা জয়েন্ট



গ

কাঠের ফ্রেম

স্টাডওয়াল নির্মাণের জন্য কাঠের স্টাড এবং সিলস, টপ পেট এবং ওয়াল পেটের সাথে যুক্ত খুঁটি দিয়ে তৈরি হয়। আনুভূমিক ব্রেসিং ব্যবহার করা হয় যাতে ভূমিকম্পজনিত এবং বাতাসের পার্শ্বিক ভারে ফ্রেমকে শক্তভাবে ধরে রাখা যায়। দেয়ালের আচ্ছাদনের জন্য বাঁশ, নলখাগড়া অথবা কাঠের বোর্ড জাতীয় বস্তু ব্যবহৃত হয়।

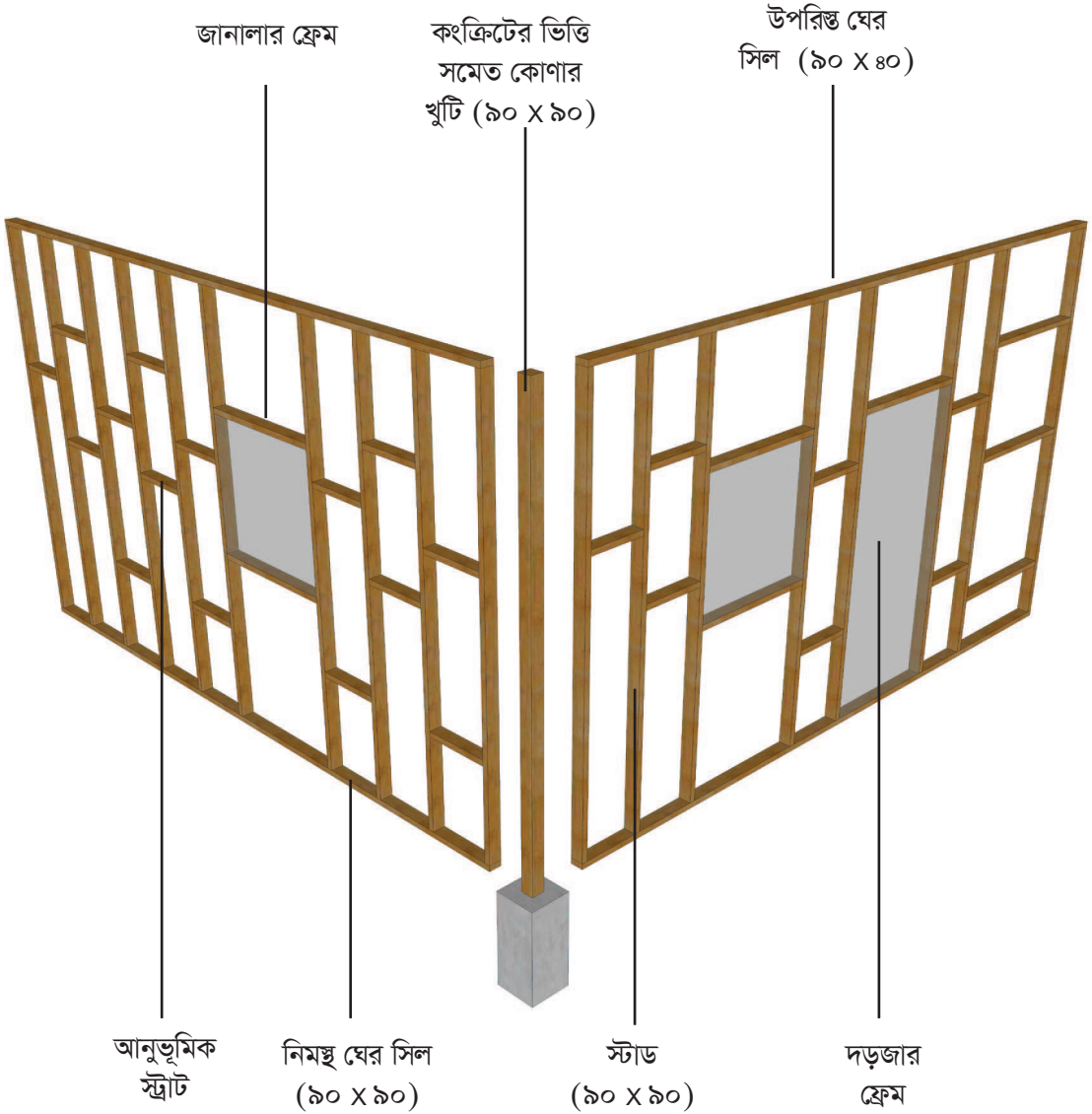
১. সিল সাধারণত ৪০ X ৯০ মিমি, ৯০ X ৯০ মিমি অথবা এর চেয়ে বড় মাপের হয়। সিলগুলো ফাউন্ডেশনের সাথে অ্যাঙ্কর বোল্টের মাধ্যমে যুক্ত থাকে যার সর্বনিম্ন ব্যাস ১২ মিমি এবং দৈর্ঘ্য ৩৫০ মিমি। সিলের সংযোগের দুপাশেই বোল্ট লাগানো হয় এবং এদের মধ্যবর্তী দূরত্ব সর্বোচ্চ ২ মিটার।

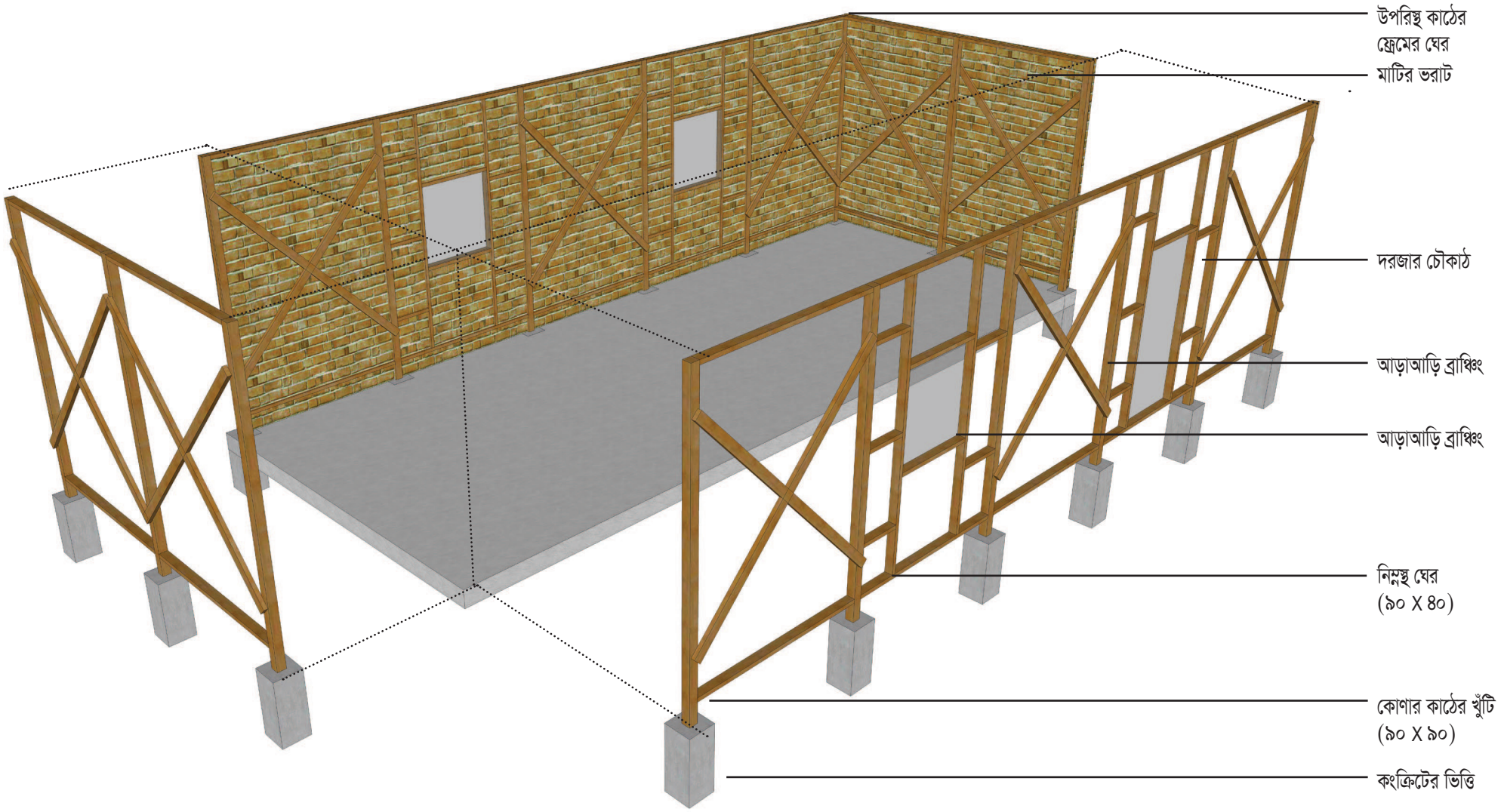
২. স্টাডের সর্বনিম্ন মাপ ৪০ X ৯০ মিমি, ৪০ X ৯০ মিমি স্টাড ব্যবহার করা হলে তাদের মধ্যবর্তী দূরত্ব ০.৫ মিটার রাখা উচিত। ৯০ ৯০ মিমি এর ক্ষেত্রে এই দূরত্ব দ্বিগুণ হবে। কিন্তু ভেতরের এবং বাইরের লাইলিং পুরু হওয়া প্রয়োজন।

৩. কোন তলার উচ্চতা ২.৭ মিটারের অধিক হওয়া উচিত না। দোতলা বাড়ির জন্য স্টাডগুলোকে ০.৫ মিটার পরপর বসাতে হবে।

৪. স্টাডের উপরের অংশ টপ পেটের সাথে যুক্ত থাকে এবং টপ পেটের মাপ স্টাডের তুলনায় কম হওয়া যাবে না।

সিলস, স্টাড এবং টপ পেট দ্বারা তৈরি ওয়াল ফ্রেমিং এর কোনাকোনি ব্রেসিং বা সিথিং বোর্ড দিতে হবে যাতে ফ্রেমিং শিয়ার অথবা ব্রেসিং ওয়াল হিসেবে কাজ করে। যদি কোন সিথিং বোর্ড না করা হয়ে থাকে, তবে সবগুলো স্টাডকে পার্শবর্তী স্টাডগুলোর সাথে আনুভূমিক বকের মাধ্যমে প্রতি ১.৫ মিটার পরপর লাগাতে হবে।




উপরিস্থ কাঠের
ফ্রেমের ঘের
মাটির ভরাট
দরজার চৌকাঠ
আড়াআড়ি ব্রাঞ্চিং
আড়াআড়ি ব্রাঞ্চিং
নিম্নস্থ ঘের
(৯০ X ৪০)
কোণার কাঠের খুঁটি
(৯০ X ৯০)
কংক্রিটের ভিত্তি

০৫ ছাদ ঃ প্রধান নীতিমালা

এরোডাইনামিক ছাদের গঠন

১. ছাদের ঢাল ৩০°-৪০° এর মধ্যে সীমাবদ্ধ রাখতে হবে যাতে বাতাসের প্রভাবে শোষণ এবং ছাদ উড়ে যাওয়া উভয়কেই মোকাবিলা করা।

২. দোচালা ছাদের চেয়ে চৌচালা ছাদকে প্রাধান্য দিতে হবে। দোচালা ছাদের ক্ষেত্রে তা কাঠামোর সাথে মজবুতভাবে আটকাতে হবে। লিন-টু বা ঠেস দেয়া বাড়ি সম্পূর্ণ পরিহার করে চলতে হবে।

৩. ঝুলন <২'-৬", ছাদে ছিদ্রপথের ব্যবস্থা থাকতে হবে এবং প্রাচীর থাকবে।

৪. আর সি সি ছাঁদ সর্বোত্তম সুরা প্রদান করে। পর্যাপ্ত পরিমাণে উলম্ব ব্রেসের জন্য এর প্রয়োজন।

কাঠামোর সাথে যুক্ত ছাদ

১. সুপারিশকৃত স্থানে রাফটার ব্যবহার করতে হবে।

২. ছাদ এবং উলম্ব কাঠামোর মধ্যে ভাল যোগাযোগ রাখতে হবে। উভয় পার্শ্বেই সাধারণ নেইলের পরিবর্তে ধাতব স্ট্রেপ এবং ওয়াশারসহ বোল্ট ব্যবহার করতে হবে।

৩. ঝুলন <২'-৬", ছাদে ছিদ্রপথের ব্যবস্থা থাকতে হবে এবং প্রাচীর থাকবে।

সুগঠিত ছাদের আচ্ছাদন

১. প্রত্যেক ভাঁজে ভাঁজে সি আই শিট লাগাতে হবে। স্বতন্ত্রভাবে টাইলস বসাতে হবে।

২. জে-হুক বোল্ট এবং থ্রেডেড/টুইস্টটেড রুফিং নেইল ব্যবহার করতে হবে।

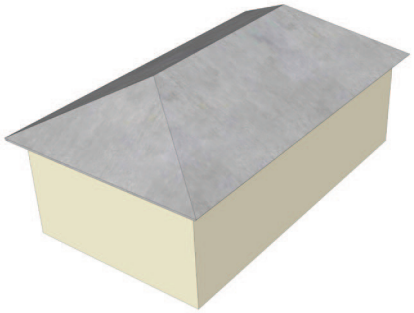
কাঠের ফ্রেম

১. নিয়মিত পরীক্ষা করতে হবে, বিশেষকরে উপরের অংশে এবং কোণায়।

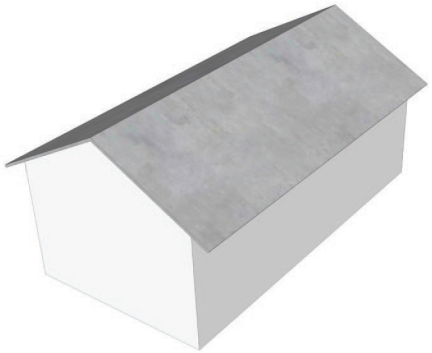
২. দুর্বল হয়ে যাওয়া অংশগুলো পরিবর্তন করতে হবে এবং ঢিলা হয়ে যাওয়া অংশগুলো মেরামত করতে হবে।

৩. বাতাসের ঝাপটায় যাতে ছাদ উড়ে না যায় সেজন্য সি.আই শিটকে শক্তভাবে কাঠামোর সাথে আটকাতে হবে।

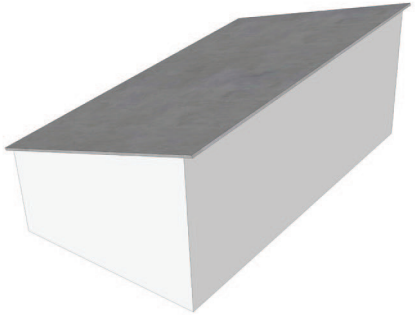
ছাদের আকৃতি



চৌচালা



দোচালা



একচালা

ক

কাঠের ফ্রেমের কাঠামো

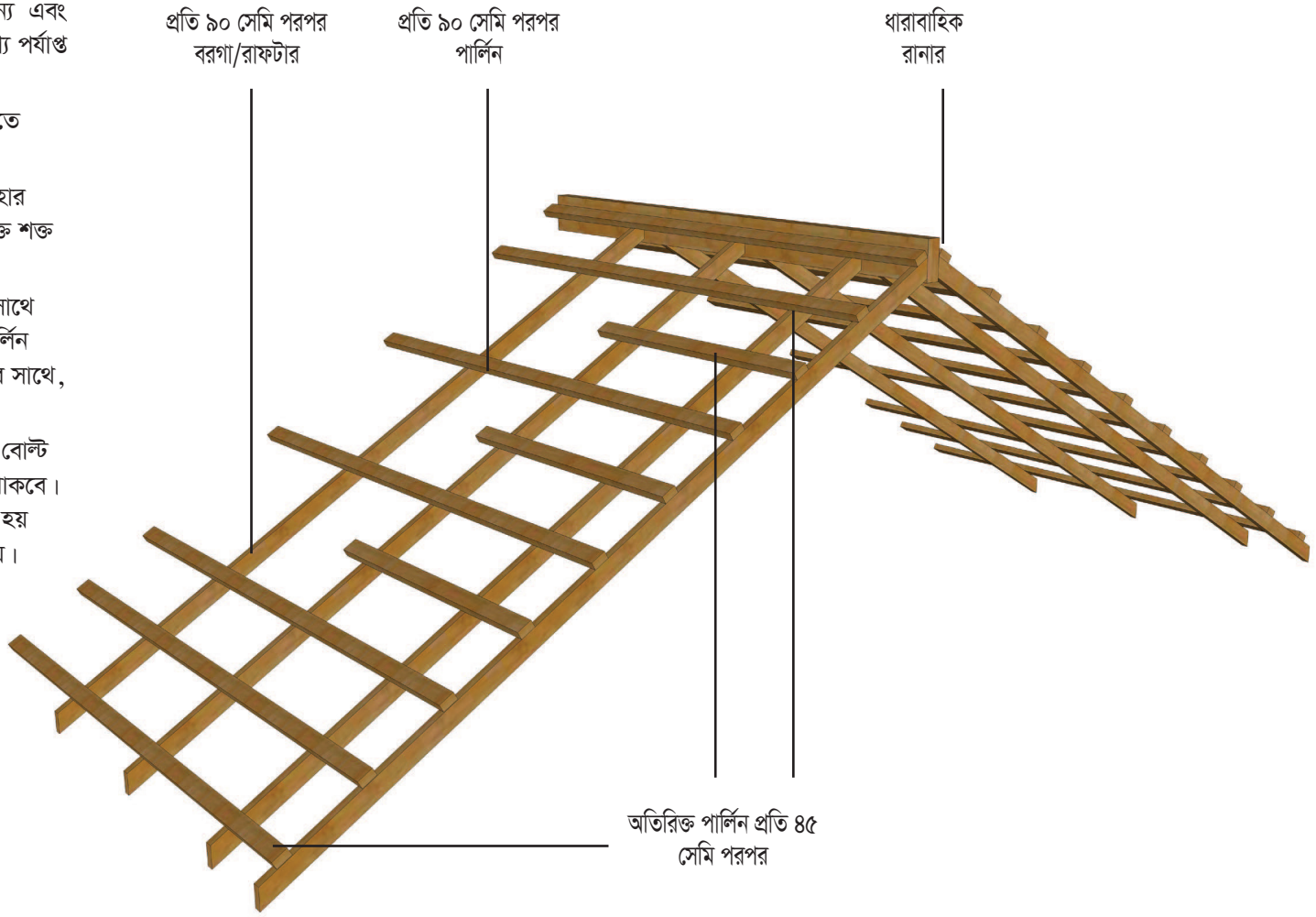
ছাদের উপর উর্ধ্বগামী বল কমানোর জন্য এবং যথাযথভাবে বৃষ্টির পানি অপসারণের উদ্দেশ্যে পর্যাপ্ত ঢালের হেলানো ছাদ ব্যবহার করা উচিত।

১. ঝুলন্ত অংশ সর্বোচ্চ ৬০০ মিলিমিটার হতে পারে।

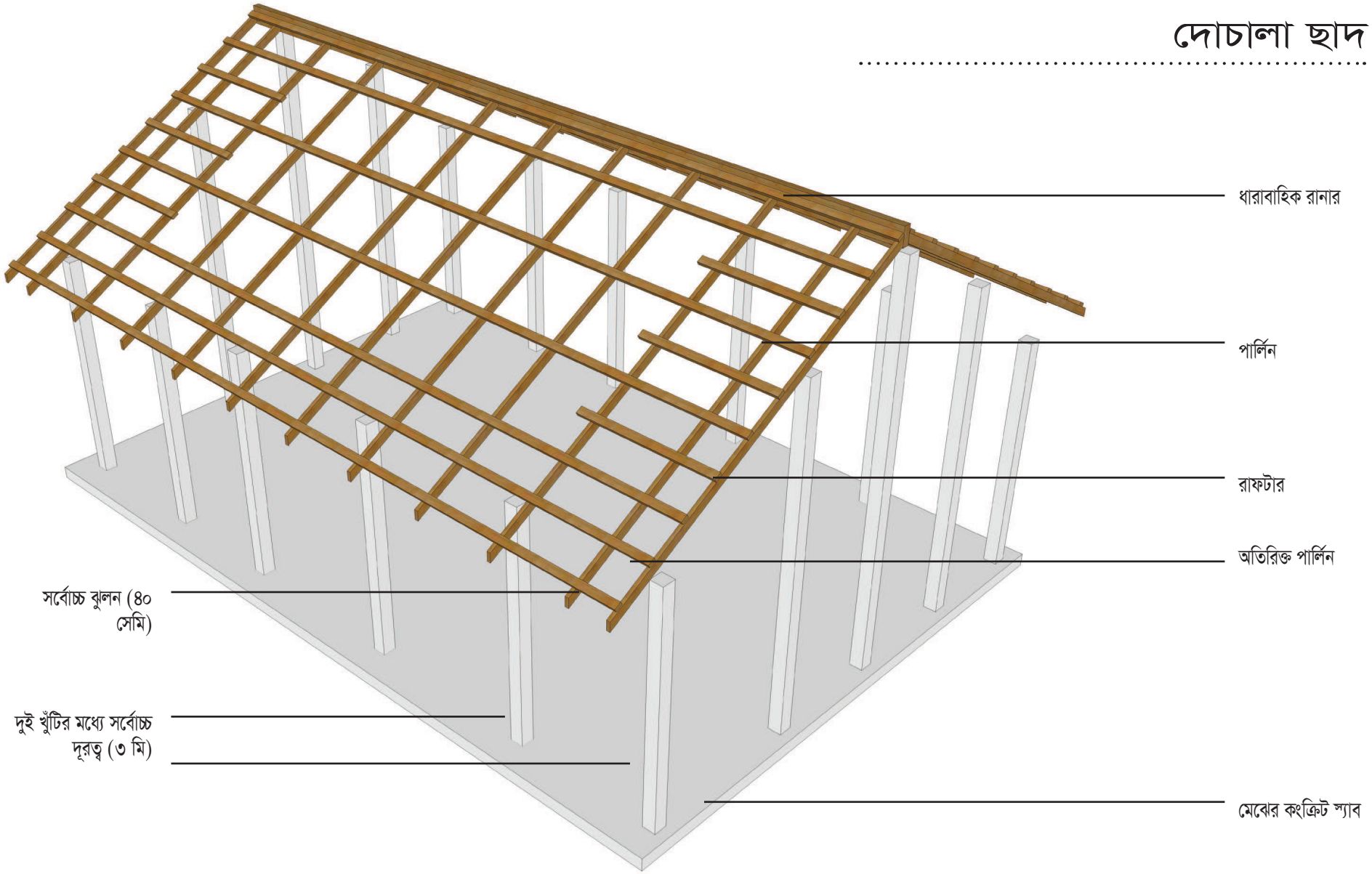
২. ছাদের কাঠামো তৈরিতে যেসব কাঠ ব্যহার করা হবে, তা অবশ্যই প্রিজারভেটিভযুক্ত শক্ত ও মজবুত কাঠ হতে হবে।

৩. ছাদ তৈরির সকল অংশ একে অপরের সাথে ভালোভাবে যুক্ত হতে হবে। যেমন- পার্লিন বরগা/রাফটারের সাথে, বরগা দেয়ালের সাথে, দেয়ালের পাত খুঁটির সাথে।

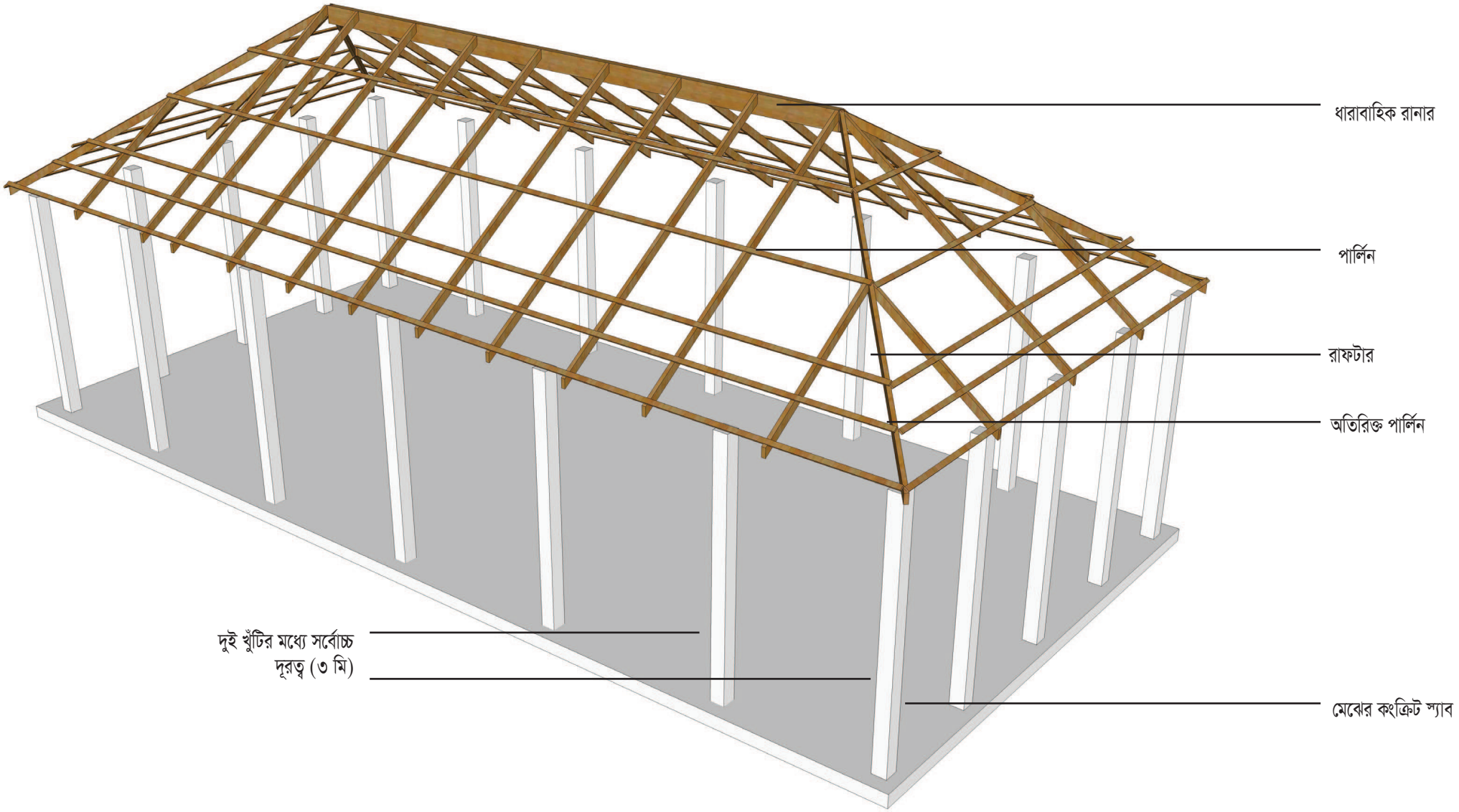
৪. ছাদের প্রতিটি শিট পার্লিনের সাথে হুক বোল্ট বা টুইস্টেড নেইলস দিয়ে আটকানো থাকবে। প্রান্তের সংযোগগুলো বেশি ঘনঘন দেয়া হয় যাতে উর্ধ্বমুখী বলকে প্রতিহত করা যায়।



দোচালা ছাদ

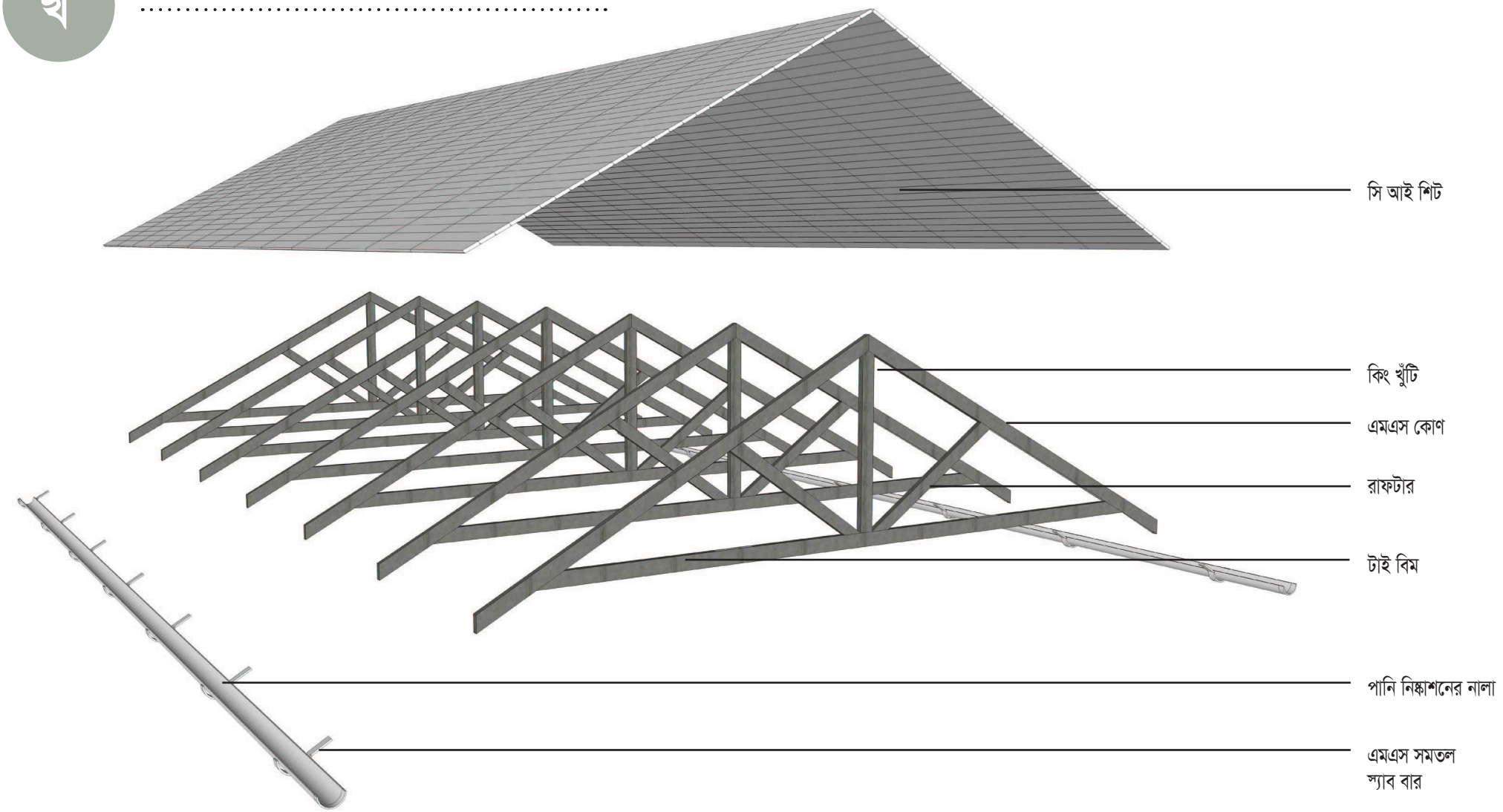

ধারাবাহিক রানার
পার্লিন
রাফটার
অতিরিক্ত পার্লিন
সর্বোচ্চ ঝুলন (৪০ সেমি)
দুই খুঁটির মধ্যে সর্বোচ্চ দূরত্ব (৩ মি)
মেঝের কংক্রিট স্যাব

চৌচালা ছাদ


ধারাবাহিক রানার
পার্লিন
রাফটার
অতিরিক্ত পার্লিন
দুই খুঁটির মধ্যে সর্বোচ্চ
দূরত্ব (৩ মি)
মেঝের কংক্রিট স্যাব

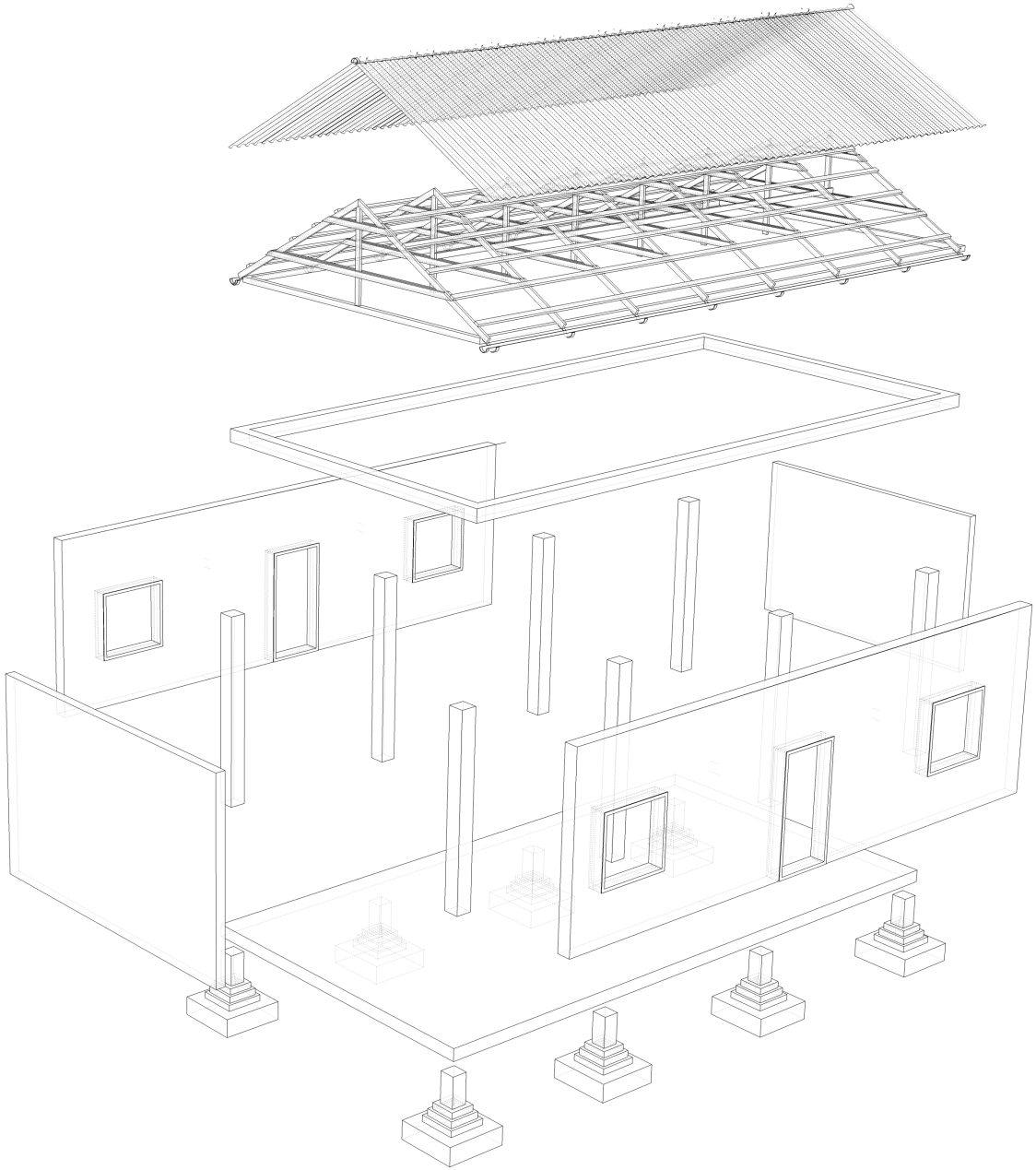
খ

ধাতব কাঠামো



বাংলা অনুবাদ ঃ মালিহা হক, স্নাতক (সম্মান) শ্রেণীর ছাত্রী, ভূগোল ও পরিবেশ বিভাগ, ঢাকা বিশ্ববিদ্যালয়, কম্পিউটার গ্রাফিক্স ঃ মোঃ মোমেন মিয়া, প্রিন্টিং ঃ এডিএস প্রিন্টিং প্রেস, ঢাকা, বাংলাদেশ

x. **Grey Building Handbook : Nepali.**



दक्षिण एसियामा विपद् उत्थानशील भवन निर्माण संहिताका अवसर र चुनौतीको बुझाइ

मध्यमार्ग

निर्माण सम्बन्धी हातेपुस्तिका

नेपाल र बाङ्लादेशको उदाहरण

एसिया-पेसिफिक नेटवर्क फर ग्लोबल चेन्ज रिसर्च (एपीएन) को अनुदान तथा कोलाबोरेटिभ रिजनल रिसर्च प्रोग्राम (सीआरआरपी) को सहयोगमा

Inspiring Excellence

एसिया-पेसिफिक नेटवर्क फर ग्लोबल चेन्ज रिसर्च (एपीएन) को अनुदान तथा कोलाबोरेटिभ रिजनल रिसर्च प्रोग्राम (सीआरआरपी) को सहयोगमा

दक्षिण एसियामा विपद् उत्थानशील भवन निर्माण संहिताका अवसर र चुनौतीको बुझाइ

नेपाल र बाङ्लादेशको उदाहरण

स्कूल अफ आर्किटेक्चर एन्ड बिल्ट इन्भारोमेन्ट, युनिभर्सिटी अफ न्युक्यासल, अस्ट्रेलिया
डा. इफ्तेकार अहमद
प्रोफेसर थायापराना गजेन्द्रन
प्रोफेसर ग्राह्म ब्रिअर
डा. किम मौन्ड
डा. जेसन भोन मेडिङ
जर्जिया किसा (अनुसन्धान सहायक)

भूगोल र वातावरण विभाग
युनिभर्सिटी अफ ढाका, बाङ्लादेश
प्रोफेसर हुमायुन कबिर
आर्किटेक्चर विभाग
ब्राक विश्वविद्यालय, बाङ्लादेश
डा. मोहमद फारूक

इन्जिनियरिङ अध्ययन संस्थान, त्रिभुवन विश्वविद्यालय, नेपाल
प्रा. डा. हरिदर्शन श्रेष्ठ
सह-प्रा. नगेन्द्रराज सिटौला
उप-प्रा. इनु प्रधान सालिके

हातेपुस्तिका डिजाइन, शब्द र चित्र
जर्जिया किसा
अनुसन्धान सहायक, युनिभर्सिटी अफ न्युक्यासल, अस्ट्रेलिया

विषयसूची

प्राक्कथन

यो हातेपुस्तिकाको प्रकाशन एसिया प्यासिफिक नेटवर्क फर ग्लोबल चेन्ज रिसर्चको सहयोगमा "दक्षिण एसियामा विपद् उत्थानशील (disaster resilience) निर्माण संहिताका अवसर र चुनौतीको बुझाइ : बाङ्लादेश र नेपालको अवस्था" नामक कोलाबोरेटिभ रिजनल रिसर्च प्रोग्राम अन्तर्गत भएको हो । बाङ्लादेशका ढाका विश्वविद्यालय र ब्राक विश्वविद्यालय अनि नेपालको त्रिभुवन विश्वविद्यालयसँगको सहकार्य रहेको यस परियोजनाको नेतृत्व अस्ट्रेलियाको युनिभर्सिटी अफ न्युक्यासलले गरेको छ ।

विश्व विपद्को निरन्तर चपेटामा छ । प्रायः गरी यस्ता विपद्को गम्भीर असर विकासोन्मुख देशमा सबैभन्दा बढी पर्ने गरेको छ । विपद्ले गर्दा विकासोन्मुख देशका अव्यवस्थित बस्तीमा बसेका गरिब जनतालाई असमानुपातिक रूपमा हानि गरेको छ । अनौपचारिक किसिमले बनाएका घर धेरै संकटासन्नता (vulnerable) मा पर्छन् । घर निर्माण र भू-उपयोग सम्बन्धी नियमावलीको व्यवस्थाले जनतालाई बढी सुरक्षित र उत्थानशील बनाउँछ र उनीहरूले सामना गर्नुपर्ने जोखिमलाई घटाउँछ । तर, अधिकांश विकासोन्मुख देशका भवन निर्माण सम्बन्धी संहिता विकसित देशका भवन निर्माण संहिताको अनुसरण गरी बनाइएका हुन्छन् । स्रोतसाधन अत्यन्त कम भएकाले, नियमावली कार्यान्वयन गर्ने व्यवस्थासमेत फितलो हुनाका साथै सामाजिक-आर्थिक अवस्थाका कारणले भवन निर्माण संहिता लागू गर्न अझ कठिन भएको छ ।

त्यसैले सुरक्षित भवन निर्माण संहिता व्यापक रूपमा लागू हुने परिस्थिति तयार गर्न विभिन्न उपाय खोज्नु सान्दर्भिक हुन्छ । तसर्थ भवन निर्माण संहिता औपचारिक क्षेत्रमा मात्र सीमित नगरी अनौपचारिक क्षेत्रमा समेत स्वतःस्फूर्त लागू गर्न उत्प्रेरित गर्नुपर्दछ ।

यस प्रक्रियालाई सहयोग पुऱ्याउनका लागि स्थानीय सन्दर्भलाई समेटी विकासोन्मुख देशहरूको सामाजिक तथा आर्थिक परिवेशमा उपलब्धिमूलक हुनेगरी यो हातेपुस्तिका तयार गरिएको छ यसमा धेरै विकल्पहरू दिइएका छन् जुन विविध आर्थिक र वातावरणीय अवस्था भएका ठाउँका मानिसले फरक फरक विकल्प अपनाउन सक्छन् । यसमा व्यक्त गरिएका सन्दर्भका उदाहरण राम्रोसँग बुझाउन र व्याख्या गर्न सकियोस् भनेर यहाँ चित्रको प्रयोग आवश्यक मात्रामा गरिएको छ । यो हातेपुस्तिक मूलतः अनौपचारिक निर्माण क्षेत्रका लागि लक्षित गरिएको हो । यसबाट स्थानीय तहमा क्षमता अभिवृद्धि गर्न मद्दत पुग्ने आशा गरिएको छ ।

परियोजना

यस परियोजनाले दक्षिण एसियामा विपद् उत्थानशीलताका लागि सुरक्षित भवन संहिताको पालना गर्ने क्रममा आइपर्ने अवसर र चुनौतीको खोजी खासगरी दक्षिण एसियाका दुईवटा देश बाङ्लादेश र नेपाललाई केन्द्रित गरी प्रकाश पारिएको छ । यी देशहरूमा हालसालै आएका विपद्ले भवन निर्माण संहिता पालना नहुनु नै मुख्य समस्या रहेको सन्दर्भलाई उजागार पारेको छ । यी दुवै देशमा भवन निर्माण संहिता बनेका त छन् तर तिनको पालना या त भएको नै छैन या न्यून मात्रामा भएको छ । अझ खासगरी व्यापक रूपमा फैलिएको अनौपचारिक निर्माण क्षेत्रमा यो समस्या विकराल छ । त्यसैले विपद्-उत्थानशील बनाउनका लागि यी निर्माण संहितालाई कसरी व्यापक मात्रामा अपनाउन सकिन्छ भन्ने विषयमा ध्यान दिन जरूरी छ । आआफ्ना देशमा विपद्को क्षेत्रमा अनुभवहरू हासिल गरेका विश्वविद्यालयहरूबीचको आपसी सहयोगले यस्ता समस्याको उचित सम्बोधन हुन सक्छ ।

नेपाल

नेपाल मूलतः डाँडाकाँडाले भरिएको र जटिल भौगोलिक बनावट भएको देश हो जहाँ विविध खालका हावापानी पाइन्छ । यस बाहेक, यसका भूगर्भमा रहेका चट्टानका प्लेटहरू चलायमान छन् । नेपाल भूकम्प, बाढी, आँधीबेहरी, पहिरो लगायतका धेरै खालका प्रकोपका कारण जोखिममा रहिआएको छ र असंख्य विपद्को सामना गर्नुपरेको छ । अव्यवस्थित शहरीकरण जस्ता मानवीय गतिविधि र अपर्याप्त भवन पूर्वाधारले विपद्को असर अझ बढ्ने गरेको छ । सन् २०१५ मा नेपालमा गएको भूकम्पले धेरै घर भत्कायो र ती घर भत्किएर किच्दा धेरै मानिसको ज्यान गयो ।

बाङ्लादेश

बाङ्लादेश प्राकृतिक प्रकोप र जलवायु परिवर्तनको सबैभन्दा बढी संकटासन्नता रहेका विश्वका देशमध्येमा पर्दछ । यहाँका प्रमुख प्रकोपहरू बाढी र तुफान हुन् । बाङ्लादेशको आधारभूत प्रकोपहरू बाढी र तुफान भए तापनि द्रुत गतिमा विस्तार भएका अव्यवस्थित शहरी क्षेत्रमा भूकम्प र आगजानीजन्य प्रकोपको पनि उत्तिकै जोखिम छ । भवन निर्माण सम्बन्धी नियम र संहिता उल्लंघन गर्ने तथा पालना नगर्ने चलनले गर्दा प्राकृतिक प्रकोप विना पनि विपद्मा परी मानिसको ज्यान जाने गरेका छन् । बाङ्लादेशमा सन् २०१३ मा राना प्लाजा गार्मेन्ट कारखाना भत्कँदा ११०० भन्दा बढी – मूलतः महिला कामदारको – मृत्यु भएको र २५०० जना घाइते भएको घटनाले यही कुराको पुष्टि गर्छ ।

हातेपुस्तिका

यस हातेपुस्तिकाले विपदोन्मुख क्षेत्रमा पटक पटक हुने प्रकोपबाट उत्थानशीलताका लागि भवन निर्माण योजना, स्थल चयन र बनावटको संरचना एवम् निर्माणसँग सम्बन्धित मुख्य मुख्य विषयमा सल्लाह, सुझाव र जरूरी जानकारी दिइएको छ । यसका लक्षित वर्ग भनेका नेपाल तथा बाङ्लादेशका स्थानीय ठेकेदार र घरधनी हुन् र यस हातेपुस्तिकाले उनीहरूलाई नै लक्षित गरी भवन निर्माण गर्दा जनधनको सुरक्षा गर्नेतर्फ प्रोत्साहित गर्ने लक्ष्य लिएको छ । निर्माण सम्बन्धी धेरै अवधारणाको वर्णन गर्न सजिलो छैन । त्यसैले यी कुरा बुझाउन र घर कसरी राम्रोसँग बनाउने भन्ने कुराको व्याख्या गर्न राम्रा अभ्यासहरूका उदाहरणका चित्र दिइएका छन् ।

हातेपुस्तिका प्रयोग गर्ने तरिका

भवन निर्माणको योजना बनाउँदा जग, खम्बा, भित्ता र छाना कस्तो बनाउँदा उपयुक्त हुन्छ भन्ने विषयमा उनीहरूको अनुभव, ठहर र छनोटले महत्वपूर्ण भूमिका खेल्छ । यस हातेपुस्तिकामा भएका धेरै विकल्पहरूले घरधनीलाई छनोटमा लचकता प्रदान गर्नुका साथै उनीहरूको सहभागिताको सुनिश्चितता गरेको छ । यसो गर्दा घरको डिजाइन बनाउँदा घरधनीलाई सहभागी गराउन सकिन्छ ।

यस हातेपुस्तिकालाई तालिम सामग्रीका रूपमा पनि उपयोग गर्न सकिन्छ । घरका मुख्य भाग निर्माण सम्बन्धी यहाँ दिइएका विभिन्न विकल्पका मूल्यांकनका आधारमा घरधनी र ठेकेदारहरूका बीचमा छलफल चलाएर प्रशिक्षकले घरको कुन डिजाइन उपयुक्त हुन्छ भन्नेबारेमा निर्णय गर्न लगाउन सक्छन् ।

यस प्रक्रियालाई सरल बनाउन तालिका पनि दिइएका छन् ।

भवन निर्माणका चरण

०१ योजना तर्जुमा

घर बनाउनुभन्दा पहिले घर बनाउन चाहेको ठाउँ र त्यहाँको वातावरण उपयुक्त छ कि छैन भनी हेर्नुपर्छ ।

भौगोलिक बनावट

उचाइ, भिरालोपन, खाल्डाखुल्डी, ढल तथा वर्षाको पानीको निकास, जमिनको अवस्था

जमिनमुनिको अवस्था

ढल तथा वर्षाको पानी जाने बाटो, पानीको निकास, सीमसार, नदी/समुद्रतट किनार, नहर किनार, खोल्साखोल्सी

पहुँच मार्ग

घर बनाउने ठाउँसम्म पुग्ने बाटो र जमिनको स्थिरतासँग सम्बन्धित विषय, सञ्चार, उद्दारका लागि बाटो

आकार

साधारण खालको समाकार जमिन छान्नुहोस् जसले गर्दा बलको तनावबाट हुने असर कम हुन्छ ।

वर्गाकार र आयाताकार (चार कुना मिलेको) जमिन उपयुक्त हुन्छ ।

०२ जग

भवनमा आइपर्ने भार जस्तै भवन तथा जग, मानिस तथा सरसामान लगायत अन्य बाह्य तत्वले दिने भारसमेतलाई जमिनमा समान वितरण गरी भवनलाई सुरक्षित बनाउनु नै जगको मुख्य काम हो ।

जग निर्माणको उद्देश्य निम्न हुन् :

१. तोकिएको सीमाभन्दा बढी जग भासिन नदिन
२. घरको भार वहन गर्न सक्ने क्षमता बढाउन र माटोको स्वरूप परिवर्तन हुन नदिन
३. स्थिर र टिकाउ बनाउन

०३

मुख्य अंग

घरको मूल अंग भवनको भार वहन गर्नका लागि उपयुक्त हुनुपर्छ । यसले जुनसुकै बाह्य अवस्थालाई प्रतिरोध गर्नुपर्छ तथा कोठामा चाहिने हावा र प्रकाश छिर्न दिनुपर्छ ।

पहिलो प्रकारको घर

ढलान र फलाम (आर.सी.सी.) राखेर बनाएको खम्बा र दलिनले भार वहन गर्ने (पिलर भएको घर) र ढुंगा तथा इँटाको भित्ता भएको ।

दोस्रो प्रकारको घर

भित्ताले नै भार वहन गर्ने (लोड बियरिङ सिस्टमको घर) ।

तेस्रो प्रकारको घर

काठको खम्बा र दलिनले बनेको माटो या अन्य सामग्री प्रयोग भएको भित्ता ।

०४

छाना

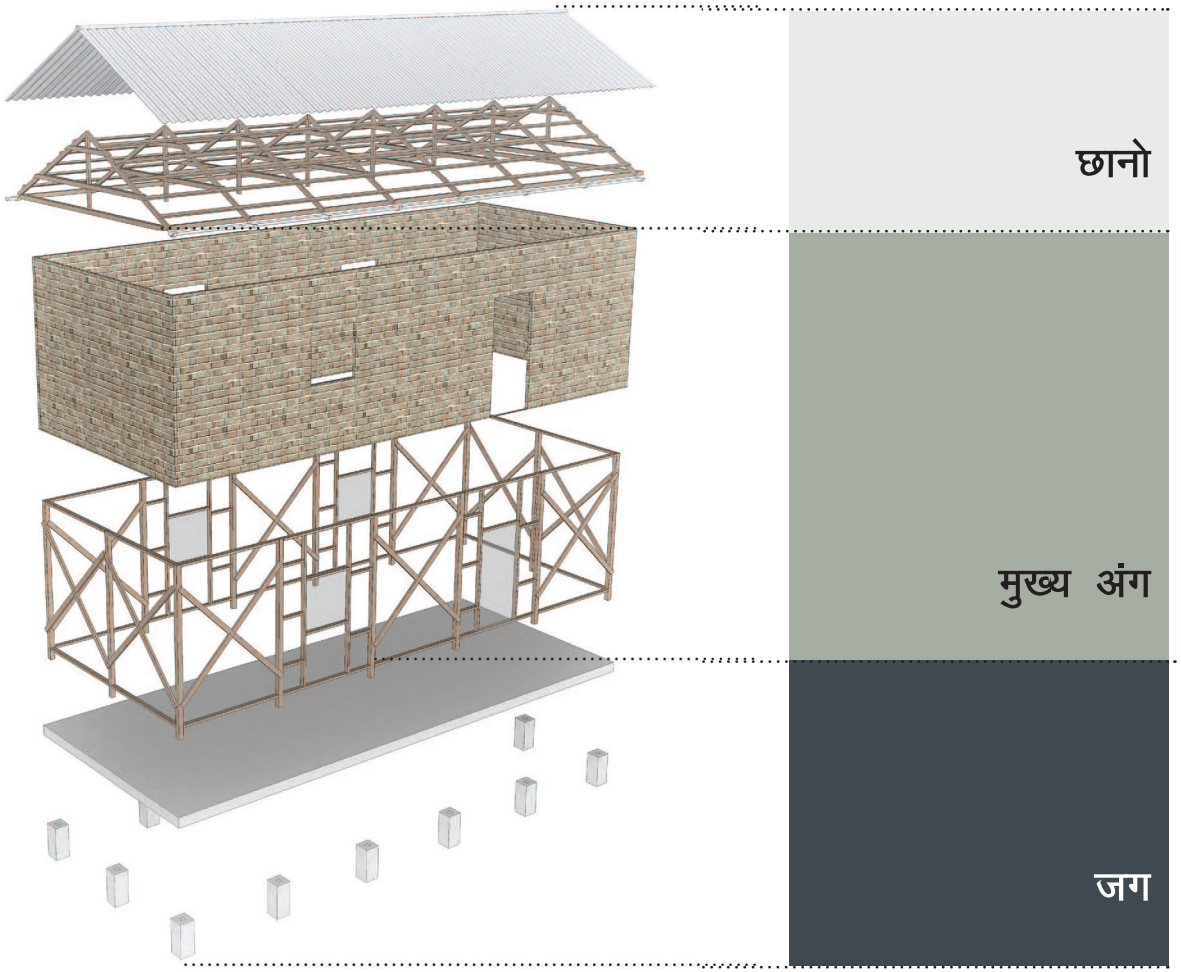
भिरालो पाखो पारेर त्यसमा जस्तापाता अथवा टायल लगाएर बनाउन सकिन्छ । डन्डी प्रयोग गरेर ढलान भएको समतल छाना पनि बनाउन सकिन्छ ।

पहिलो प्रकारको छानो

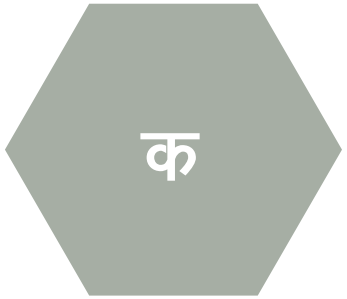
फलामे डन्डी राखेर ढलान गरेको छानो ।

दोस्रो प्रकारको छानो

काठका डाँडाभाटा (ट्रस) बनाई त्यसमाथि जस्ता तथा अन्य पाता/टायल आदिले छाएको ।

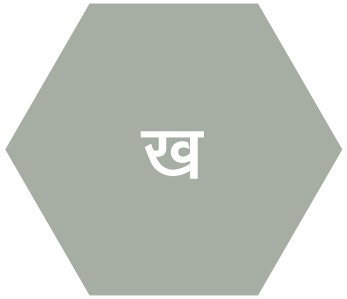


निर्माणका विभिन्न विकल्प



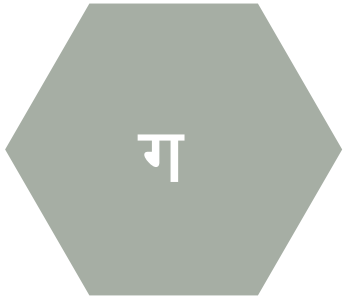
जग

अनवरत जोडिएको जग



खम्बा

आर.सी.सी. पिलर वा काठका खम्बा



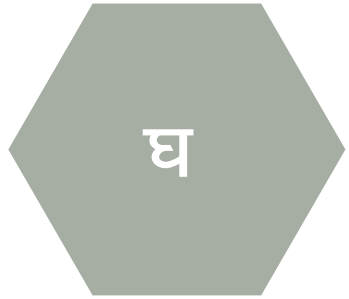
भित्ता

इँटा/ढुंगा

कंक्रिट ब्लक

माटाको ब्लक

हल्का सामग्रीहरू
(काठ, बाँस, फुसको भित्ता)



छानो

आर.सी.सी. ढलान

काठको डाँडाभाटामाथि जस्ता तथा
अन्य पाता/टायल

बर्सातको पानी बग्ने डुँड

०१ योजना तर्जुमा

घरले हावाको कत्ति ठूलो धक्का थेग्न सक्छ भन्ने कुरा घरको स्वरूप, घर हावाको बहावको कुन दिशामा अवस्थित छ भन्ने कुरा, निर्माण सामग्रीको गुणस्तर र आधारभूत डिजाइनको संरचनागत बनावटमा भर पर्छ ।

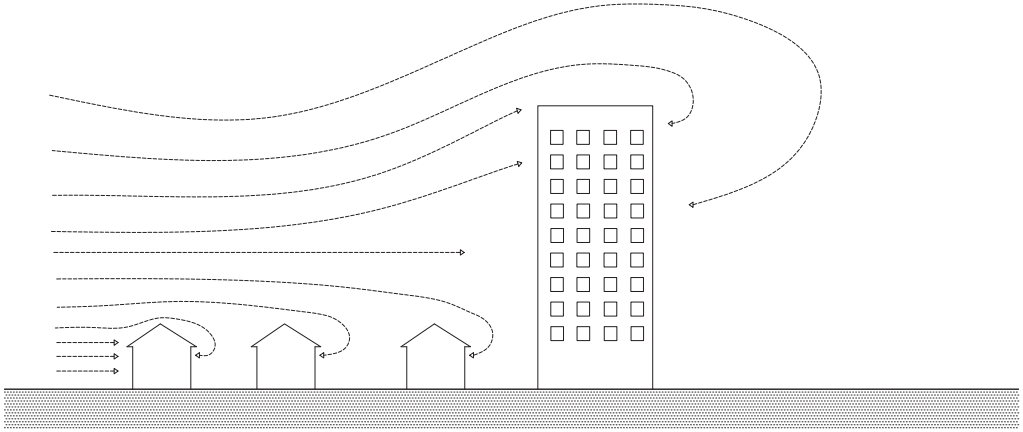
चक्रावत आएका बेलामा अग्ला घरले होचा घरलाई केही हदसम्म सुरक्षा प्रदान गर्छन् ।

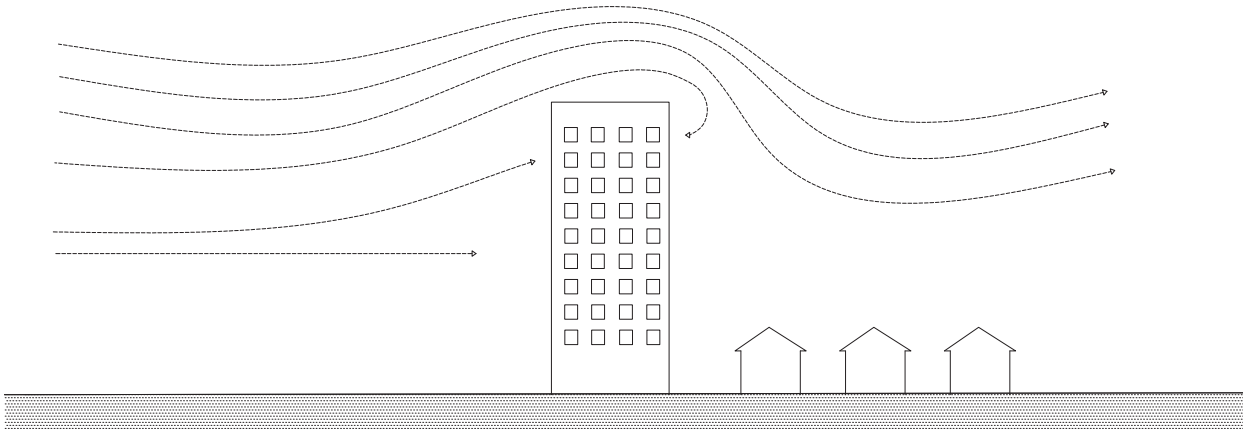
चक्रावतको विपद् भएका ठाउँमा निर्माण स्थलको योजना बनाउँदा बीचबीचमा अग्ला भवन बनाएर तिनलाई आँधी रोक्ने साधनका रूपमा उपयोग गर्नेतर्फ विचार गर्नुपर्छ ।

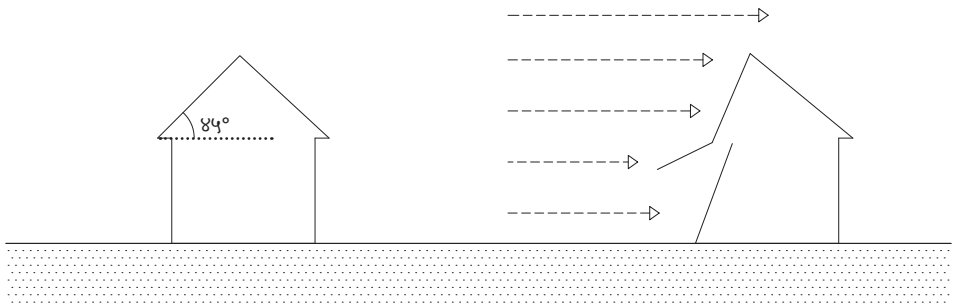
अर्कातिर, अग्ला भवनले गर्दा भुँवरी सिर्जना पनि हुन सक्छ, स्थानीय हावा उल्टो दिशामा वहन पनि सक्छ, आँधी सिर्जना हुन सक्छ र हावाले कुनै पनि वस्तुलाई आफूतिर तान्ने अवस्था बन्न सक्छ ।

हावा आउने दिशामा बनेका अग्ला घरका पछाडि आडमा बनाइएका घरमा हावाको प्रकोप कम हुन्छ । भिरालो पाखाको किनारामा र समुद्रतिर फर्केका भिराला उपत्यकामा घर बनाउनुहुन्न ।

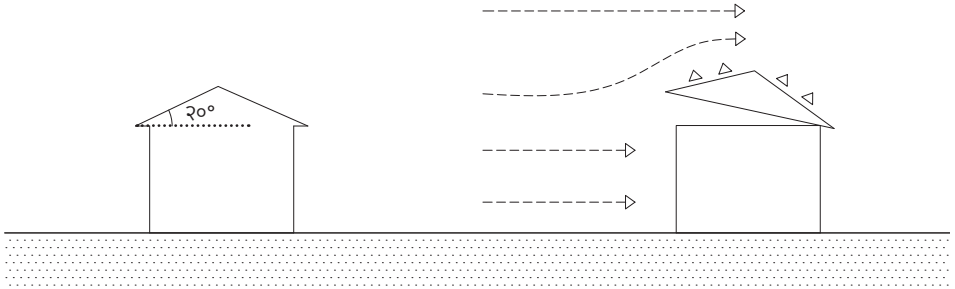
लम्बाइ अति धेरै भएको घर बनाउनुहुँदैन किनभने यसो गर्दा सीधा, खुला र समानान्तर बाटो भएर हुरी वहन र हुरीको गति बढेर 'हावाको भुमरी' बनी असर पर्ने हुनालेअति लामो हुनेगरी कुनै पनि संरचना बनाउनुहुँदैन ।





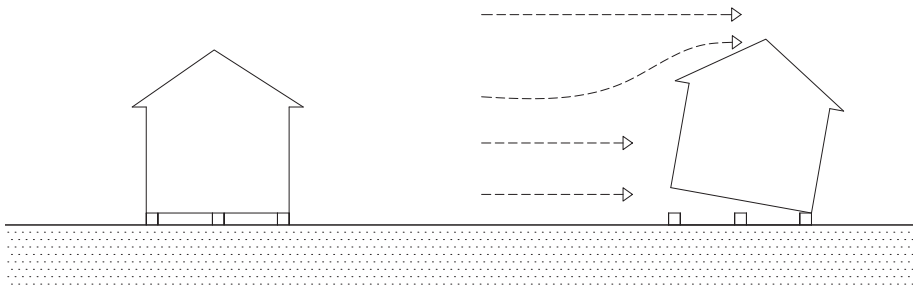


धेरै भिरालो छाना भएको घरमा हावाको धक्का धेरै पर्न सक्छ जसले गर्दा छानाभित्र हावा पसेर त्यसले छानो उडाउन सक्छ ।



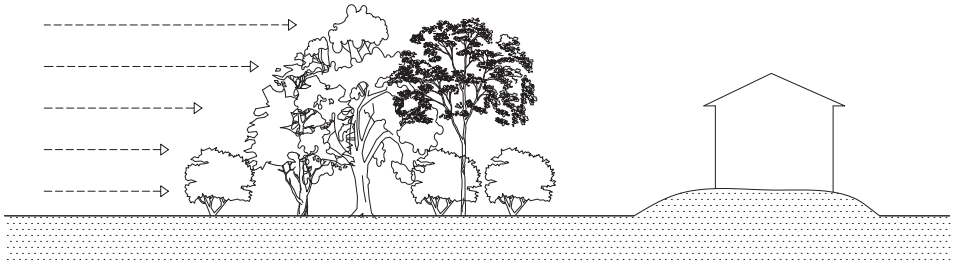
कम भिरालो छाना भएको घरको छानालाई बढी हावाको खिचाइले उडाउन सक्छ ।

सामान्यतया, ३० ° कोणको भिरालो छानामा हावाको धक्का सबैभन्दा कम पर्छ ।

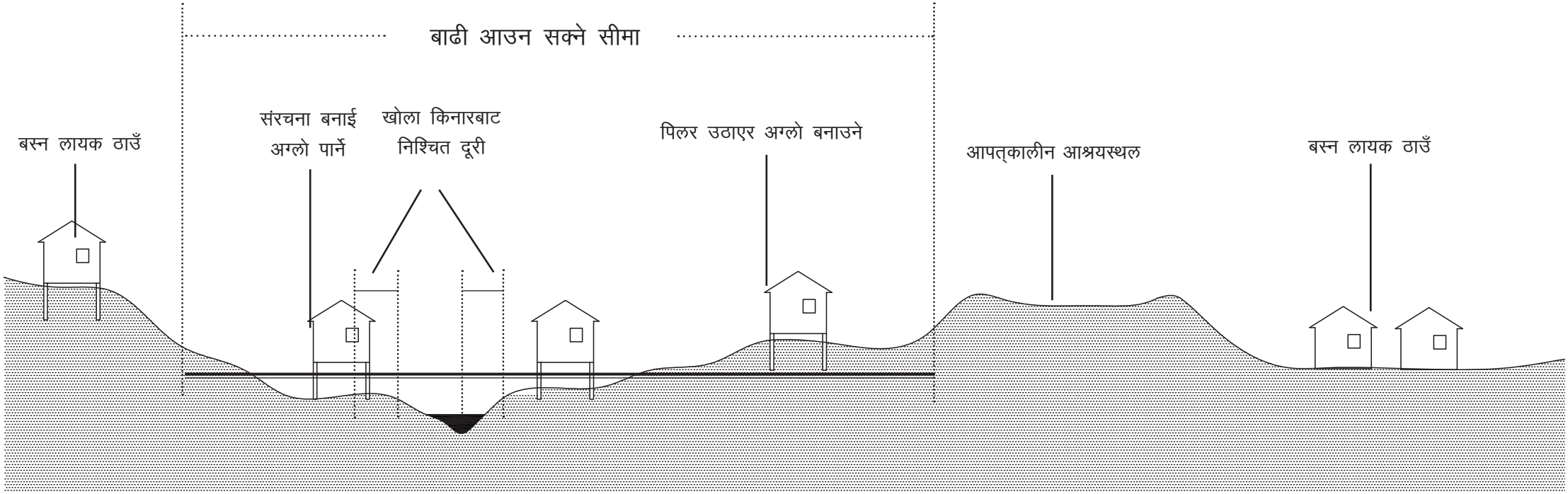


भवन बनाउँदा जगसँग राम्ररी कसिएको छैन भने भवनका अन्य भागहरू जतिसुकै राम्रोसँग बनाइए पनि त्यस्ता भवन पल्टिन सक्छन् ।

जोर्नी दह्रोसँग नकसीकन बनाइएका घरका अंगहरू बांगिन सक्छन् ।



हावाको बहाव छेक्न हावा आउने दिशातिर रोपिएका अग्ला रूखको उचाइ बराबरको दूरी घरबाट हुनेगरी रूख रोप्ने गरेमा हुरीबतासबाट घर सुरक्षित हुन्छ ।



भवन बनाउने ठाउँ छान्दा जमिन कत्तिको स्थिर छ भन्ने कुरामा ध्यान दिनुपर्छ । साथै, बाढी अथवा आँधीको शक्तिशाली धक्का नआउने ठाउँ छान्नुपर्छ ।

चोसाचासी निस्केका घरभन्दा आयाताकार घर बढी भूकम्प प्रतिरोधी हुन्छन् । लामो तथा साँधुरो आयाताकार ब्लकहरूमा समेत जमिन हल्लिदाको बटारिने असरको मात्रा बढी हुन्छ ।

त्यसैले भवनको चौडाइ र त्यसको लम्बाइको अनुपात १:३ भन्दा बढी हुनुहुँदैन । लम्बाइ धेरै चाहिएको छ भने अलग अलग भवन बनाई ती दुई भवनका बीचमा पर्याप्त खाली ठाउँ छोड्नुपर्छ ।

हरेक भवन (खण्ड) का बीचमा नियमितता र समानाकार कायम राख्नका लागि ठूलो भवनलाई विभिन्न खण्डमा टुक्र्याउनुपर्छ ।

भवन निर्माण क्षेत्रलाई चक्रावत आँधी र हावाको धक्काबाट जोगाउनका लागि तटबन्ध गर्नुपर्छ । समुद्री छालको चाप घटाउनका लागि समुद्रतिरको भागमा ढुंगाको तटबन्ध बाँध्नुपर्छ । तटबन्धको भित्रपट्टिको भागमा जरा धेरै तलसम्म जाने रूख लगाउनुपर्छ जसले गर्दा जमिन बाँधिन्छ र भूक्षय हुन पाउँदैन ।

खासगरी नदीका फराकिला मुहानको कारण चक्रावतको असर जमिनको भित्री भागतर्फ बढी परेको हुन्छ । त्यसबाट बाढीसमेत आउन सक्छ । त्यसैले बाढीले असर गर्न नसक्ने खालको आपत्कालीन उद्धार मार्ग र विस्थापितहरूका लागि आश्रयस्थलको व्यवस्था गर्नुपर्छ ।

०२ जग

क

अनवरत जग

माटाको जग उठाउनका लागि माटो र सिमेन्टको मिश्रणलाई ३:१ भागमा मिसाउनुपर्छ । यसरी मिसाएको मिश्रणलाई तीन हप्तासम्म पानी पटाएर चिसो राख्नुपर्छ ।

वैकल्पिक उपाय : स्थिर माटोको अग्लो जग ।

ख

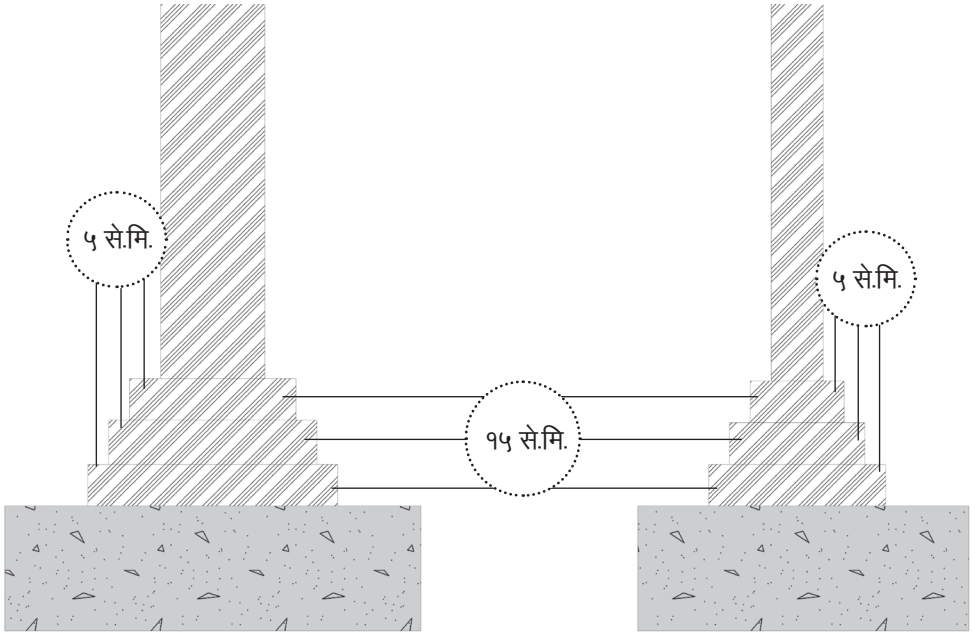
हात्तीपाइले जग (फुटिङ)

खम्बाको हात्तीपाइले जग

- पिलरको जग एकापसमा नजोडीकन बेग्लाबेग्लै हात्तीपाइले जग राख्ने ।
- यसले पिलरबाट आउने सम्पूर्ण केन्द्रीकृत भारलाई जमिनमा समान रूपमा सबैतिर बराबरी बाँड्छ ।
- सामान्यतया, वर्गाकार, आयाताकार अथवा गोलाकार फुटिङ बनाउन सकिन्छ ।
- जमिनको भार वहन क्षमता र भवनले वहन गर्नुपर्ने भार (वजन) हेरेर इँटा, ढुंगा अथवा आर.सी.को फुटिङ पनि बनाउन सकिन्छ ।

पर्खालको फुटिङ र डन्डी सहितको ढलानको जग

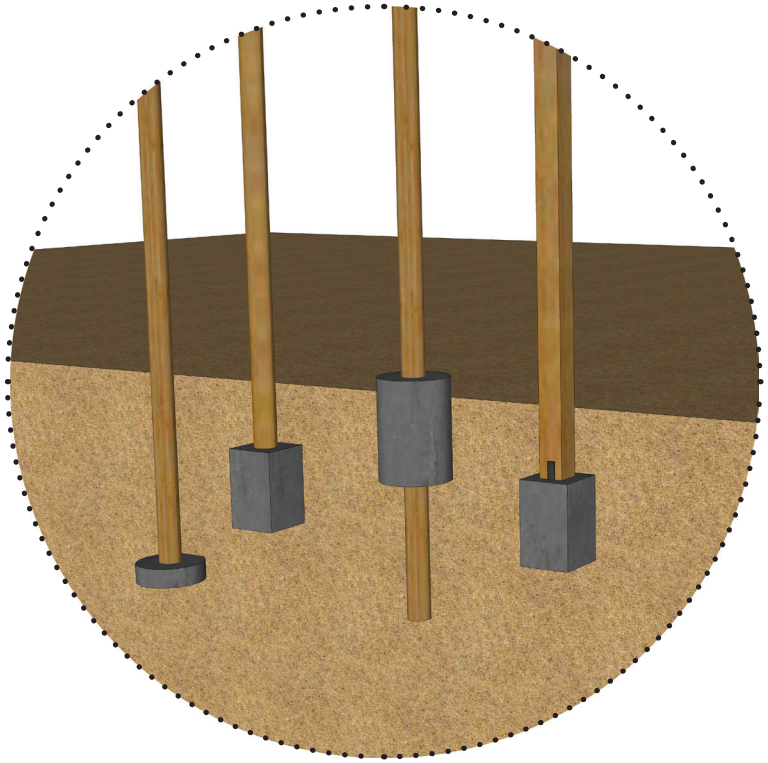
- इँटाका धेरै तह जसमा सबैभन्दा तलको तह माथिको गारोको चौडाइभन्दा दोब्बर हुनुपर्छ ।
- फराकिलो आधारका लागि ५ से.मि.को अफसेट (आट), हरेक फुटिङको तह कम्तीमा एउटा इँटाको मोटाइ बराबर हुनुपर्छ । कहिलेकाहीं सबैभन्दा तलको तह दुईवटा इँटा बराबर मोटो पनि हुन सक्छ ।
- कंक्रिटको पातलो तह, कम्तीमा १५ से.मि. मोटाइ, हरेक साइड (पाटा) मा १०-१५ से.मि.को आट (प्रोजेक्सन), यसको मोटाइ जगमाथिको आट (प्रोजेक्सन) को मोटाइभन्दा कम हुनुहुँदैन ।
- जगको ढलानको तहले पर्खालको फुटिङ राख्नका लागि समतल सतह बनाउँछ, खन्दा बनेका खाल्डाखुल्डी मिलाउँछ र जमिनको नरम सतहहरूलाई भर्ने काम गर्छ ।
- भार धेरै थाम्नुपर्ने छ भने र जमिनको भारवहन क्षमता कम छ भने डन्डी राखेको फुटिङ गर्न सकिन्छ । यस्तो अवस्थामा डन्डी सहितको ढलानको फुटिङ राखिएन भने ठूलो पर्खाल बनाउनुपर्ने हुन्छ जुन ज्यादा खर्चिलो हुन्छ ।
- डन्डी सहितको ढलानको फुटिङ तल ७-८ से.मि.को पातलो ढलानको तह अनिवार्य बनाउनुपर्छ ।



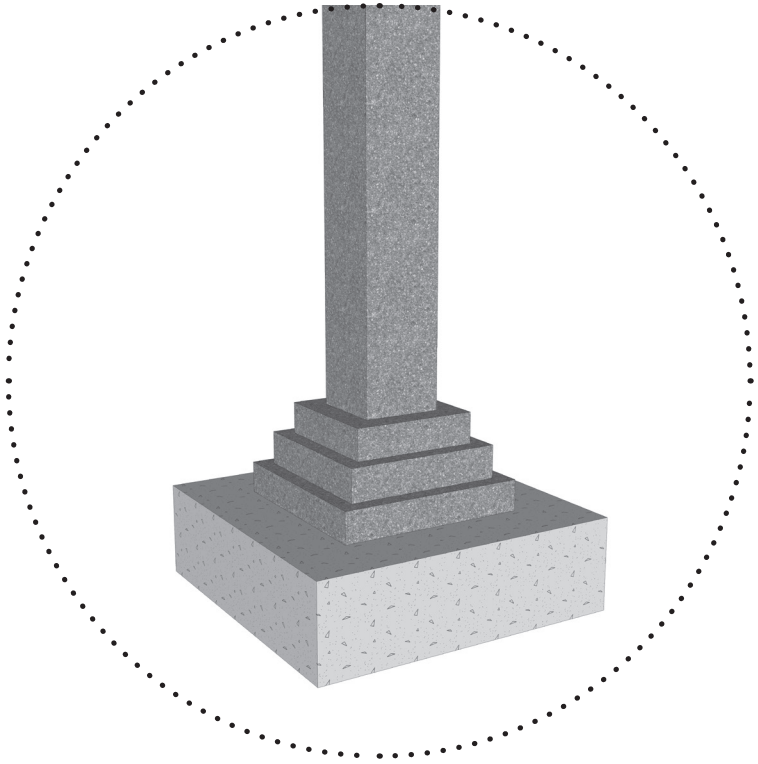
पर्खालको चौडाइ
२५ से.मि.

पर्खालको चौडाइ
१२.५ से.मि.

फुटिङका प्रकार



काठ/बाँसको खम्बाको फुटिङ



कंक्रिट/इँटाको खम्बाको फुटिङ

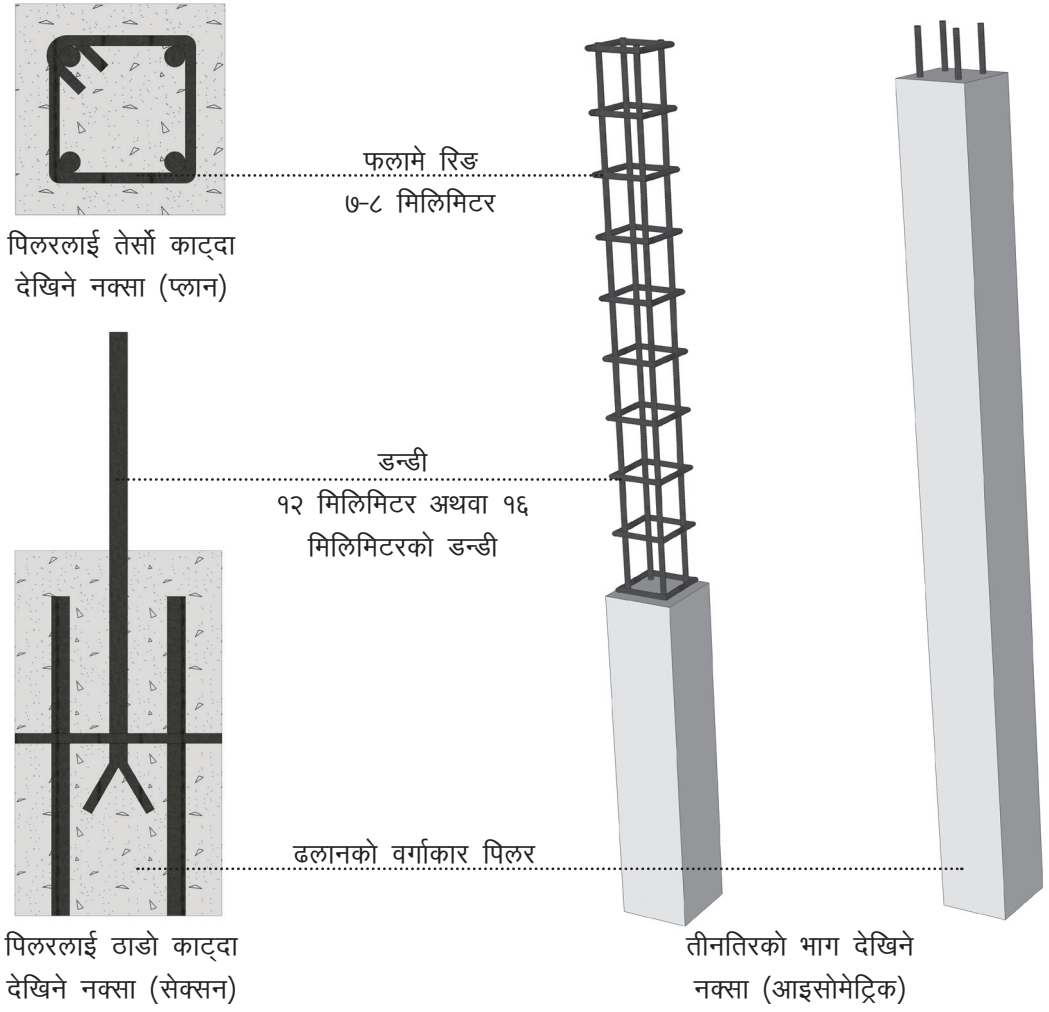
०३ खम्बा

ग

डन्डी सहितको ढलानको खम्बा

१. ढलानको मिश्रणमा "सिमेन्ट, बालुवा र गिटी" को अनुपात सामान्यतया "१:२:३" अथवा "१:२:४" हुनुपर्छ ।
२. फलामको डन्डी सहितको ढलान बनाउँदा तलका मध्ये कुनै एक खालको डन्डी प्रयोग गर्न सकिन्छ : क) माइल्ड स्टिल र टोरस्टिल डन्डी ख) उच्च क्षमताको डिफर्म्ड डन्डी ।
३. फलामे डन्डीमा खिया, रङ, तेल, माटो लगायतका डन्डीलाई हानि गर्न सक्ने वा त्यसलाई ढलानसँग जोडिन नदिने कुनै पनि पदार्थ लागेको हुनुहुँदैन । १५ मिलिमिटरका चारवटा डन्डीलाई ८ इन्च (२०० मिलिमिटर) को रिङ (चुरी) ले बाँध्ने । दुईवटा रिङबीचको दूरी सामान्यतया ८-१० इन्चभन्दा बढी हुनुहुँदैन ।
४. वर्गाकार पिलर कम्तीमा ३०x३० सेन्टिमिटर (१२x१२ इन्च) का हुनुपर्छ । दुईवटा पिलरबीचको दूरी ४.५ मिटर (१४ फिट ९ इन्च) भन्दा बढी हुनुहुँदैन ।
५. पर्खाल, छाना र जगलाई एकापसमा जोडेर मजबुत पार्न डन्डी राखेर ढलानको फ्रेम (चौकोस) बनाउनुपर्छ र ढलान छाना छ भने त्यसले पनि फ्रेमको काम गर्न सक्छ ।
६. झ्यालढोका या अन्य पर्खाल नभएका खुला ठाउँमा ढलानको ब्यान्ड (लिन्टेल) राख्ने गर्नुपर्छ ।

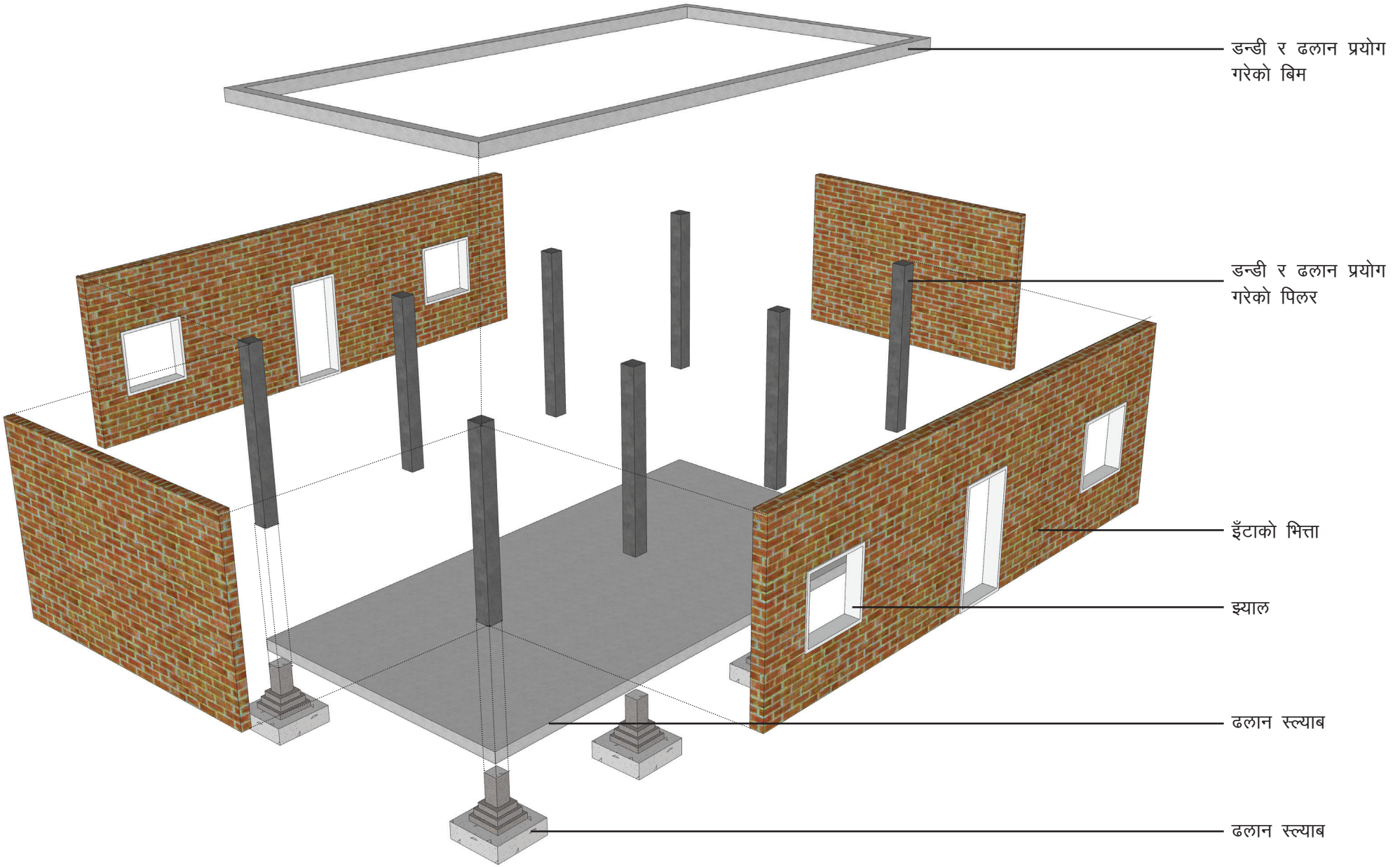
विवरण



पिलरलाई तेर्सो काट्दा देखिने नक्सा (प्लान)

पिलरलाई ठाडो काट्दा देखिने नक्सा (सेक्सन)

तीनतिरको भाग देखिने नक्सा (आइसोमेट्रिक)


डन्डी र ढलान प्रयोग गरेको बिम
डन्डी र ढलान प्रयोग गरेको पिलर
इँटाको भित्ता
झ्याल
ढलान स्ल्याब
ढलान स्ल्याब

०४ पर्खाल

क

भार वहन गर्ने भित्ता

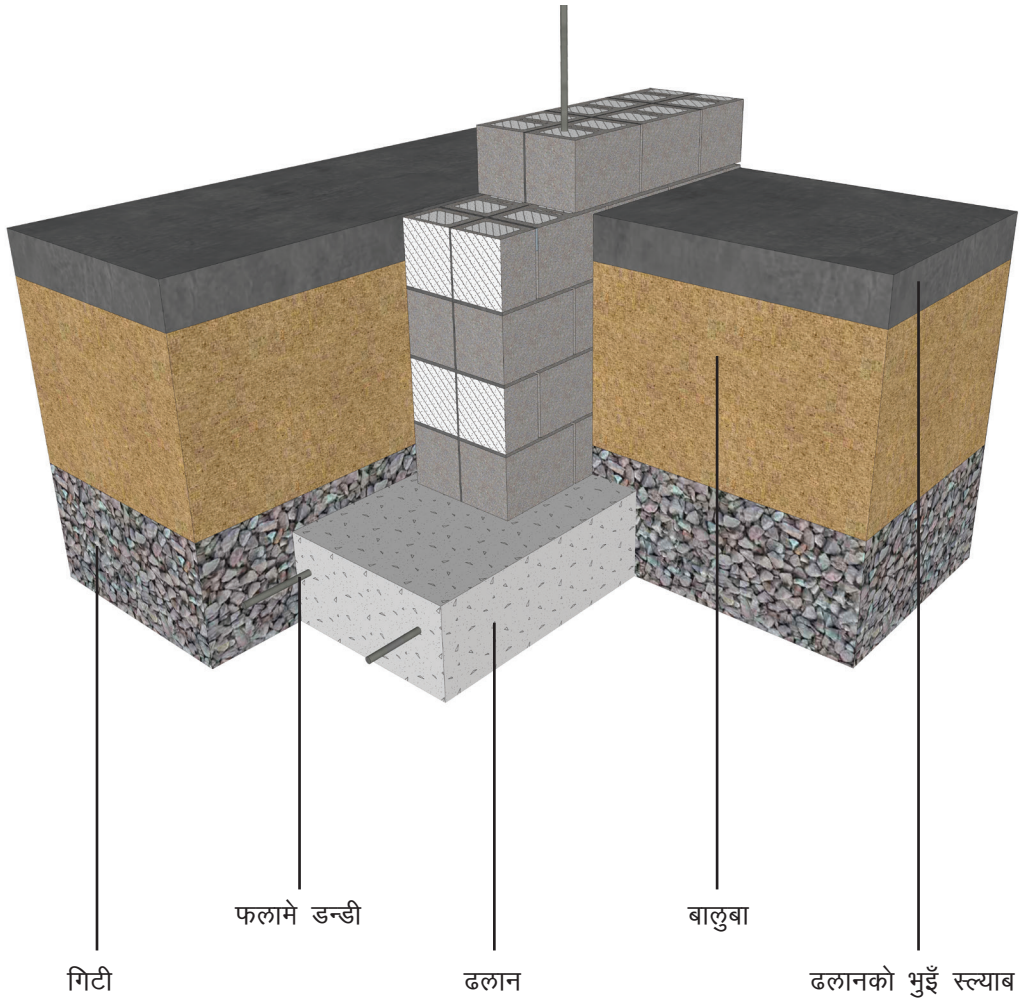
माइल्ड स्टिल डन्डी, हुप आइरन तथा फलामे जालीको प्रयोग गरी गारोलाई बलियो बनाउन सकिन्छ र यसले थप भार वहन गर्नुका साथै भूकम्पीय र हावाको चापबाट आउने धक्का थेग्न सक्छ ।

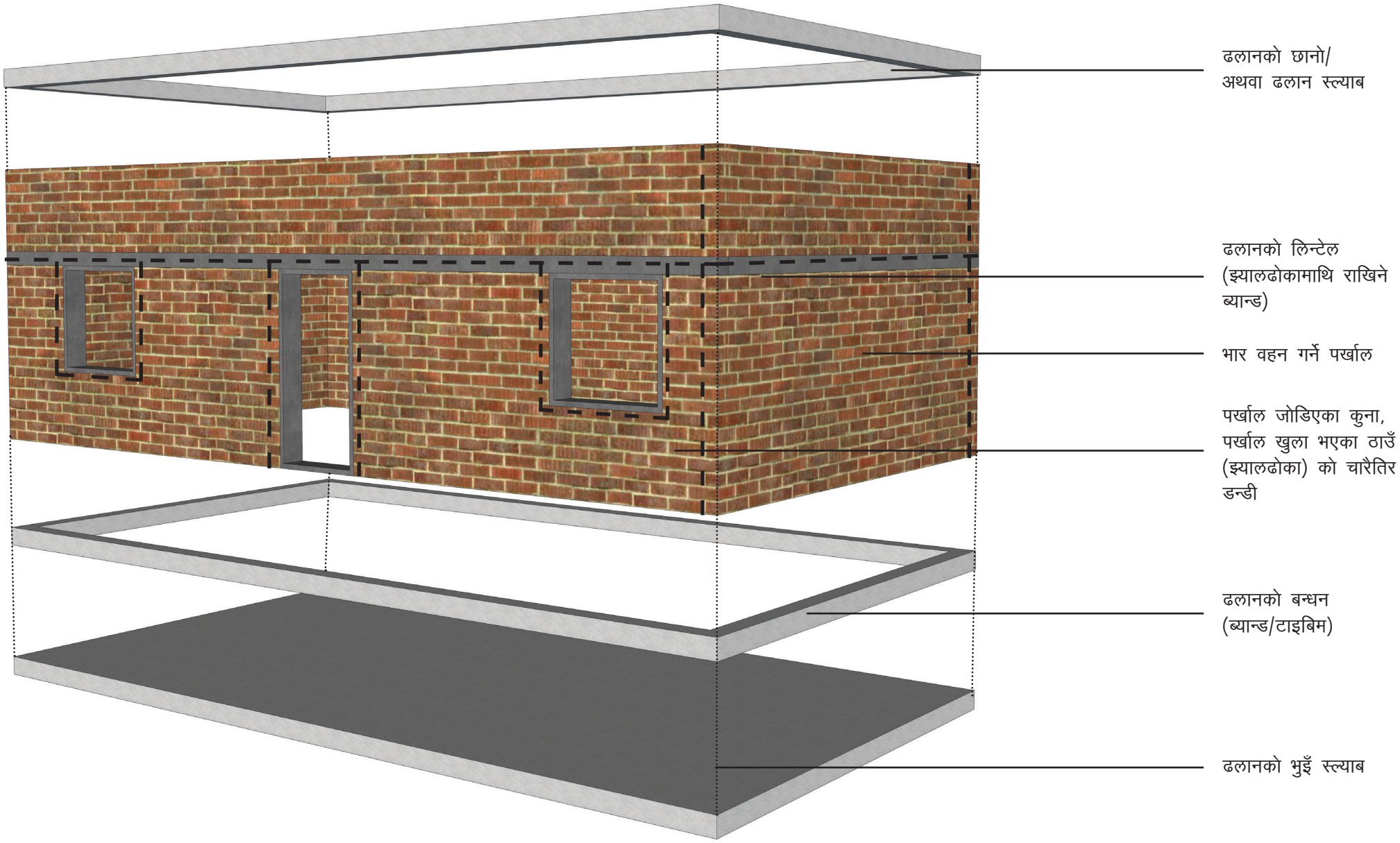
झ्यालढोका र दुईवटा पर्खाल नजोडिएको लामो पर्खाल बनाउँदा यदि होलो ब्लक लगाउने भए हरेक १.२ मिटरको अन्तरमा र सोलिड इँटा लगाउने भए हरेक २ मिटरको अन्तरमा डन्डी राखेर ढलानको ब्यान्ड हाल्नुपर्छ ।

डन्डीमा खिया नलागोस् भन्नाका लागि डन्डीको वरिपरि कम्तीमा १५-२५ से.मि.को ढलान (कभर) ले छोप्नुपर्छ ।

इँटाको पिलर र भुइँको स्ल्याबलाई पनि डन्डी राखेर थप बलियो गर्नुपर्छ ।

पर्खालका लागि समेत जगमा ढलान हुनुपर्छ । इँटाको पर्खाल (गारो) लगाउँदा जगमा डन्डी सहितको ढलान गरी गारोको हरेक कुना र जोडहरूमा डन्डीलाई खडा गरी लगाउनुका साथै झ्यालढोका आदिका कुनामा पनि डन्डी राख्नुपर्छ । यसरी गारो लगाउँदा डन्डीलाई १.२ मिटरको दूरी नबढाई राख्नुपर्छ ।



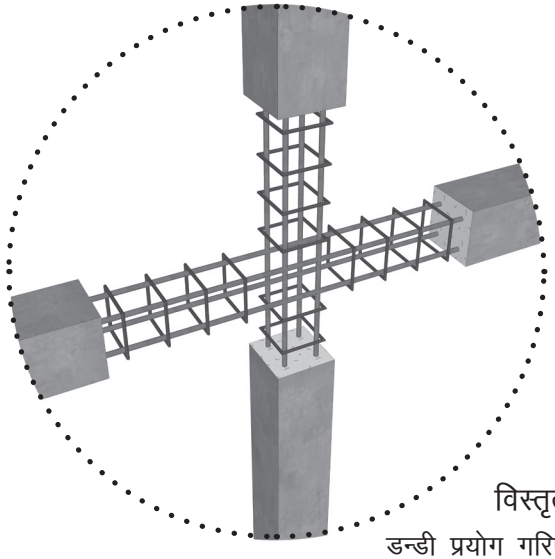

ढलानको छानो/
अथवा ढलान स्ल्याब
ढलानको लिन्टेल
(झ्यालढोकामाथि राखिने
ब्यान्ड)
भार वहन गर्ने पर्खाल
पर्खाल जोडिएका कुना,
पर्खाल खुला भएका ठाउँ
(झ्यालढोका) को चारैतिर
डन्डी
ढलानको बन्धन
(ब्यान्ड/टाइबिम)
ढलानको भुइँ स्ल्याब

ख

डन्डी प्रयोग गरेको पर्खाल

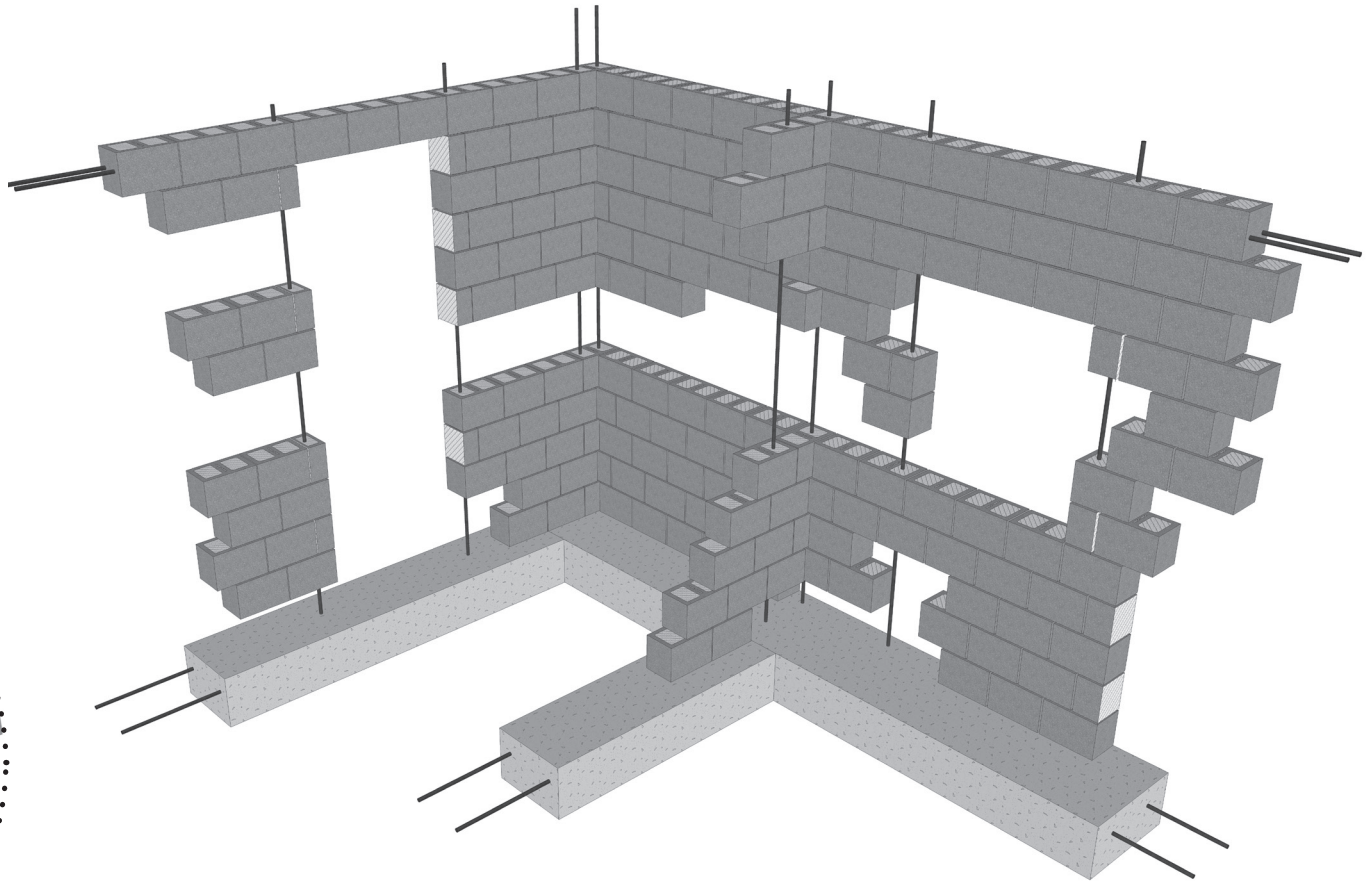
घरको पर्खालका सबै कुना र दुई पर्खालका जोडहरूमा तथा झ्यालढोकाको चौकोस वरपर सबै ठाउँमा ब्यान्ड राख्नुपर्छ ।

लोड बियरिङ भवनलाई तेर्सो र ठाडो डन्डी राखेर भुइँचालोको धक्काबाट जोगाउनुपर्छ । भार वहन गर्ने पर्खालबाट बनेको भवनमा ठाडा र तेर्सा ब्यान्ड राख्नुपर्छ ।



विस्तृत नक्सा

डन्डी प्रयोग गरिएको ढलानको जोर्नी



ग

काठको फ्रेम

काठको घरमा चारै कुनाको काठको खम्बालाई झ्यालमुनिको भाग, झ्यालमाथिको भाग र पर्खालमाथि राखिने प्लेटले बाँधिएको हुन्छ । भूकम्प र हावाको धक्का धान्न सक्ने बनाउन सबै कुनालाई बिमले कसेर बलियो बनाइएको हुन्छ । यस्ता घरको पर्खाल (भित्ता) बाँस, पटेर वा काठ जस्ता हल्का सामग्रीले बनेको हुन्छ ।

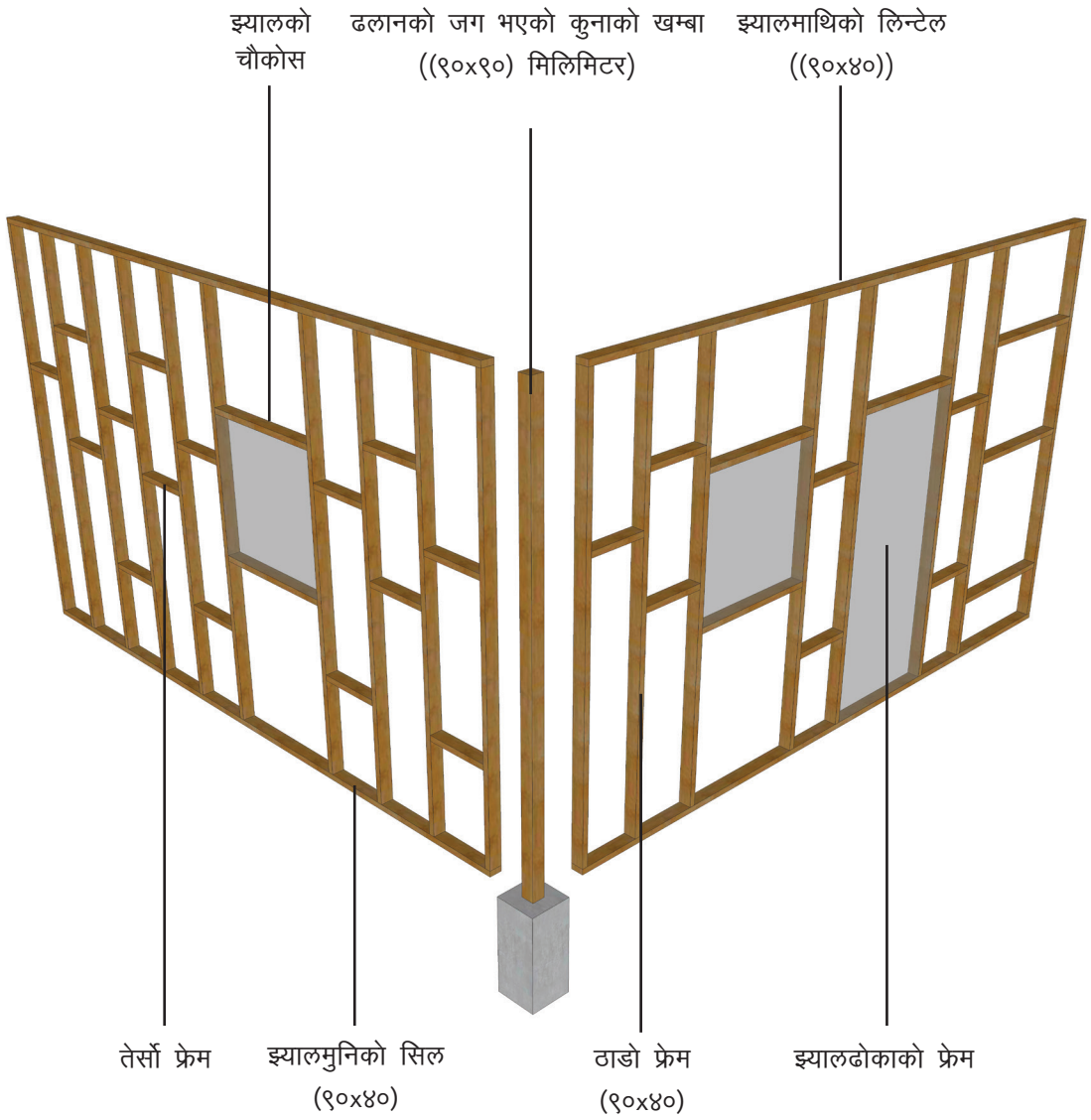
१. झ्यालको तलको भाग ४०x९० मिलिमिटर, ९०x९० मिलिमिटर अथवा त्योभन्दा ठूलो हुनुपर्छ । झ्यालको तलको भागलाई दुवैतिरबाट एंकर बोल्टले जगसँग जोडेको हुन्छ । यस्तो बोल्टको गोलाइ १२ मिलिमिटर र लम्बाइ ३५० मिलिमिटर हुनुपर्छ । जोर्नीको दुवैतिर एंकर बोल्ट राख्नुपर्छ । दुईवटा बोल्टबीचको अधिकतम दूरी २ मिटर मात्र हुनुपर्छ ।

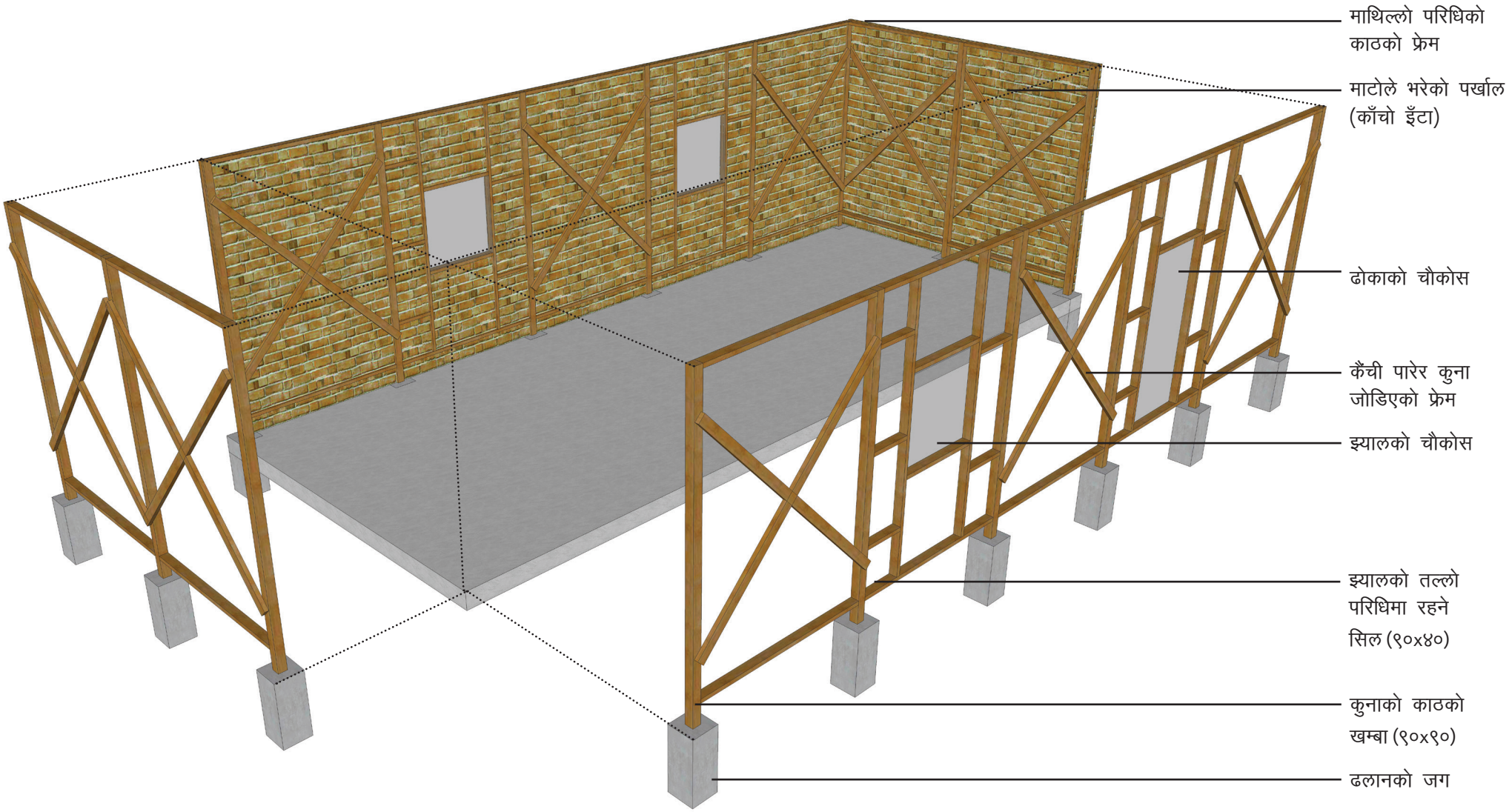
२. फ्रेमको न्यूनतम नाप ४०x९० मिलिमिटर हुनुपर्छ । दुईवटा फ्रेमबीचको अधिकतम दूरी ०.५ देखि १ मिटर मात्र हुनुपर्छ । यदि फ्रेम ४०x९० को छ भने दुईवटा फ्रेमबीचको दूरी ०.५ मिटर मात्र हुनुपर्छ र यदि फ्रेम ९०x९० को छ भने दुईवटा फ्रेमबीचको दूरीलाई दोब्बर पार्न सकिन्छ तर यसो गर्दा भित्री र बाहिरी लाइनिङ मोटो बनाउनुपर्ने हुन सक्छ ।

३. यस्ता घरको तलाको उचाइ २.७ मिटर (८ फिट ९ इन्च) भन्दा बढी हुनुहुँदैन । दुईतले घरका लागि हरेक ०.५ मिटरमा फ्रेम राख्नुपर्छ ।

४. फ्रेमको सबैभन्दा माथिको भागलाई टप प्लेटसँग जोड्नुपर्छ । टप प्लेटको नाप फ्रेमको नापभन्दा कम हुनुहुँदैन ।

५. वाल फ्रेमिङमा भएका झ्यालमुनिको भाग, फ्रेम र झ्यालमाथिको प्लेट एकापसमा कुनामा कैंची जस्तो पारेर जोडेमा या फलेकले समेत कसिएको हुँदा यिनले एकाकार भई भार लिन सक्छन् । फलेकले बाँधिएको छैन भने सबै फ्रेमलाई कम्तीमा १.५ मिटरको उचाइमा तेर्सो फ्रेमले जोड्नुपर्छ ।




माथिल्लो परिधिको काठको फ्रेम
माटोले भरेको पर्खाल (काँचो इँटा)
ढोकाको चौकोस
कैंची पारेर कुना जोडिएको फ्रेम
झ्यालको चौकोस
झ्यालको तल्लो परिधिमा रहने सिल (९०x४०)
कुनाको काठको खम्बा (९०x९०)
ढलानको जग

०४ छानो : आधारभूत सिद्धान्त

हावाको गति अनुसारका छानाका प्रकार

१. ३०-४० डिग्री भिरालो छानोले चाप उत्पन्न हुने र छानो उडाउने जोखिम घटाउँछ ।
२. चुच्चीमा पर्खाल नभएको छानो । चुच्चीमा पर्खाल लगाउने हो भने त्यसको छेउलाई घरको पर्खालसँग राम्ररी जोड्नुपर्छ । एकपाखे छाना सकेसम्म बनाउनुहुँदैन ।
३. छानो पर्खालबाट २ फिट ६ इन्चभन्दा बढी बाहिर निकाल्नुहुँदैन ।
४. ढलान गरिएको छानोले धेरै राम्रोसँग सुरक्षा दिन्छ तर यसलाई पनि ठाढा डन्डी राखेर पर्खालसँग राम्ररी जोड्नुपर्छ ।

छानोलाई घरको पर्खालसँग जोड्ने तरिका

१. डाँडाहरू तोकिएको दूरीमा राख्नुपर्छ ।
२. छानाको पाखालाई छड्के फ्रेमले बाँध्नुपर्छ ।
३. छानोलाई पर्खालसँग मजबुत पाराले जोड्नुपर्छ । यसका लागि फलाममा पाता राखी सामान्य कीलाले होइन दुवैतिर वासर भएका बोल्टले कस्नुपर्छ ।

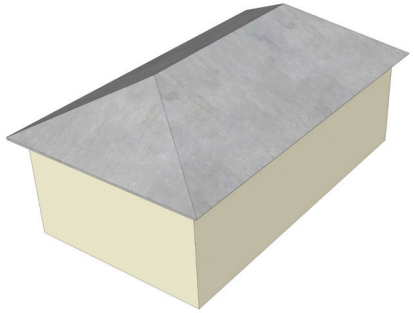
छानो छाउने सही तरिका

१. टायल लगाउने हो भने हरेक टायल बाँधिएको हुनुपर्छ । जस्तापाता लगाउने हो भने त्यसका डिलमा कीला ठोक्नुपर्छ ।
२. यसका लागि अंग्रेजी 'जे' आकारको हुकबोल्ट अथवा स्क्रु (गुणन) भएको अथवा ट्विस्टेड कीला प्रयोग गर्नुपर्छ ।

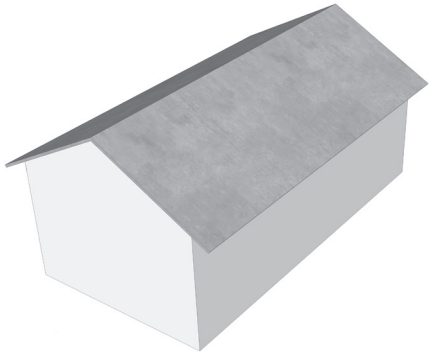
नियमित मर्मत

१. छानोको विशेषगरी धुरी र कुनाको नियमित जाँच गर्नुपर्छ ।
२. बोल्ट र काठ कमजोर भएका वा खुस्कन लागेका छन् भने तिनलाई हटाएर नयाँ राख्नुपर्छ ।
३. जस्तापातालाई कस्ने हुक या कीलालाई हावाको धक्का थेग्न सक्ने बनाउन समय समयमा कस्नुपर्छ ।

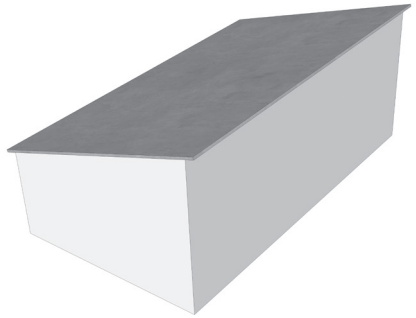
छानाको आकार



चुच्चीको पर्खाल नभएको
(hipped roof)



चुच्चीको पर्खाल भएको
(gable roof)



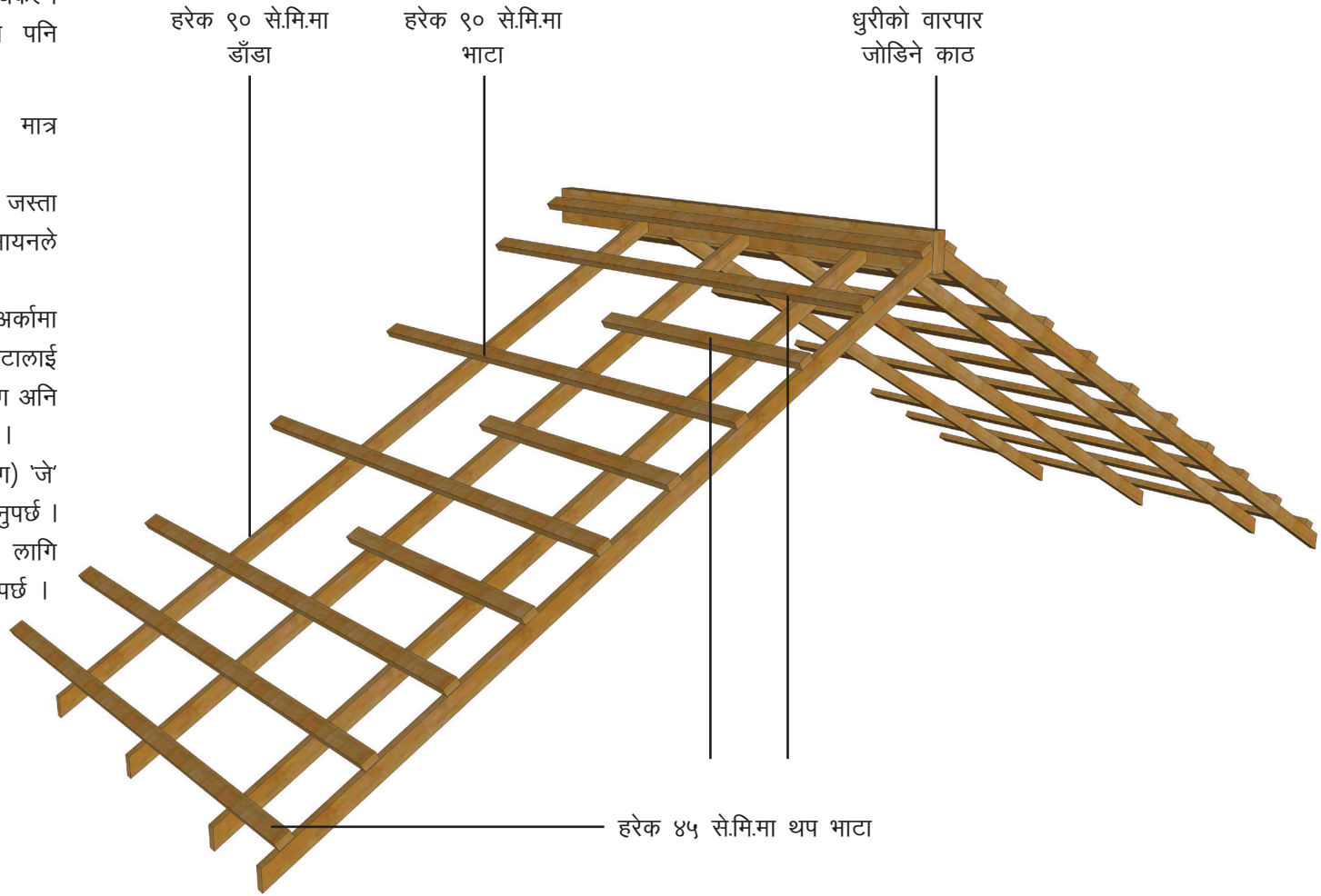
एक पाखे छानो
(lean-to-roof)

क

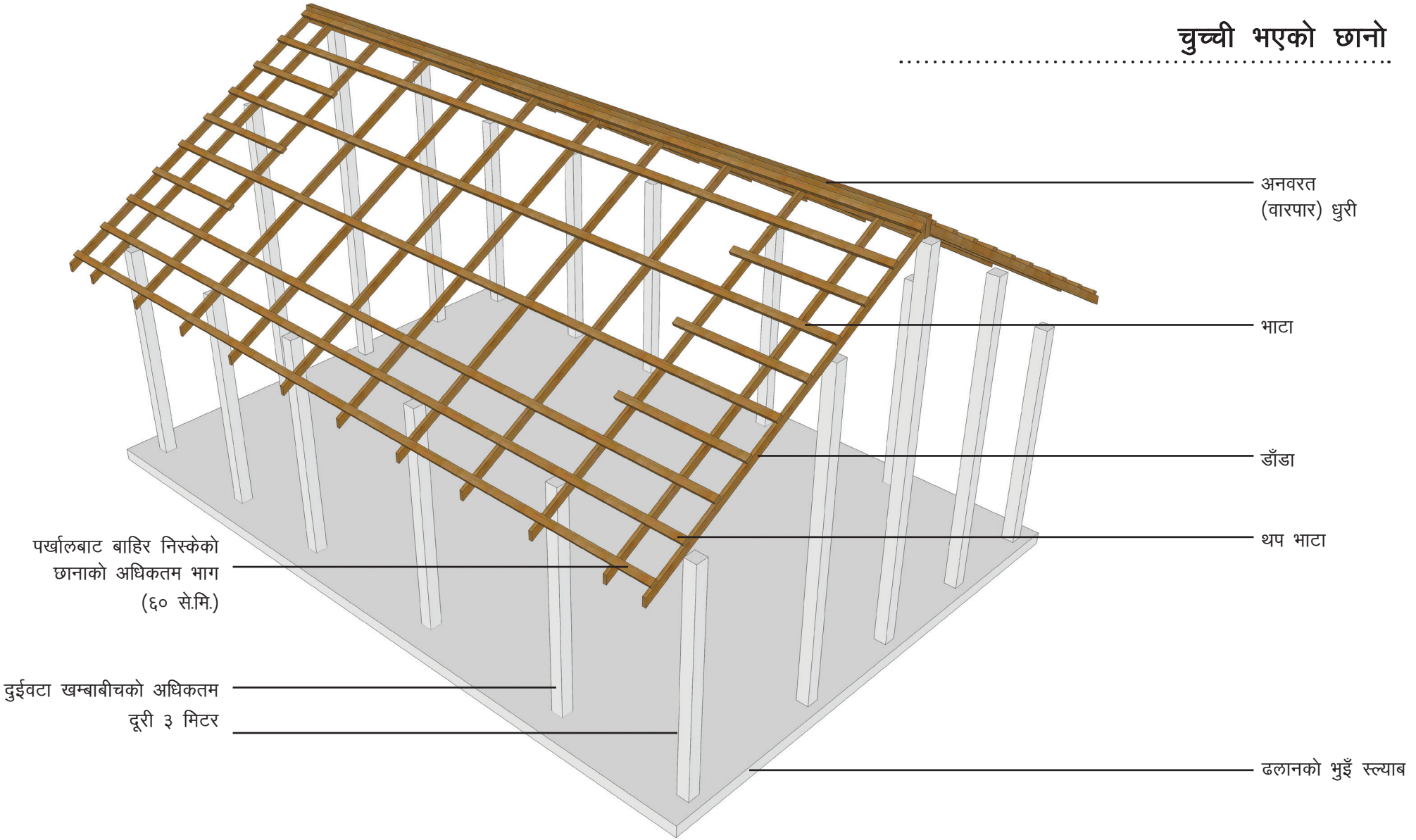
काठको फ्रेमको बनावट

छानो पर्याप्त भिरालो भएको (२५ डिग्रीभन्दा बढी) बनाउँदा यसले छानोलाई हावाले माथि धकेल्ने जोखिम घटाउँछ र छानामा परेको पानी पनि राम्रोसँग तर्किन्छ ।

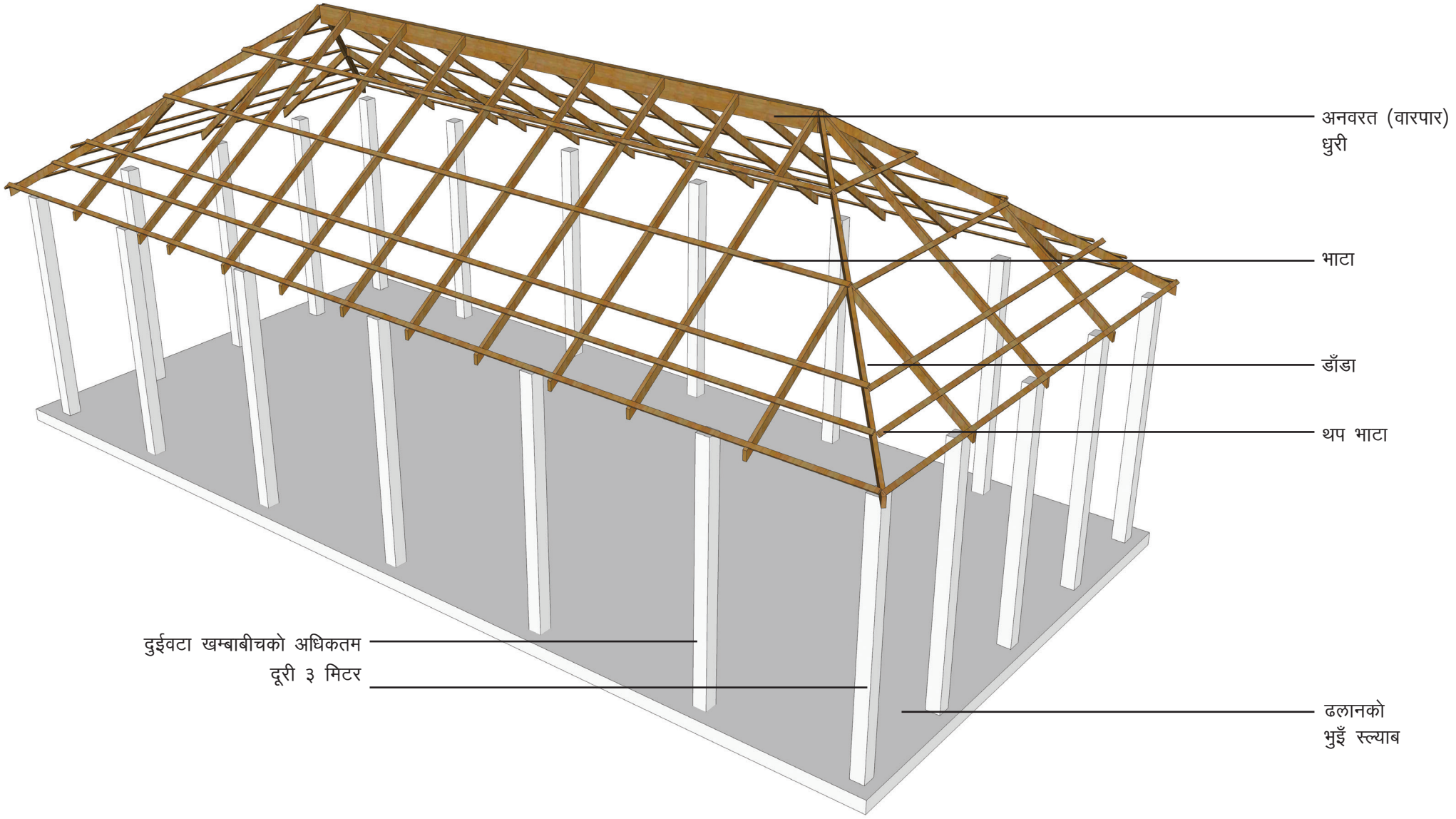
१. छानो पर्खालबाट बढीमा ६०० एम.एम. मात्र निस्केको हुनुपर्छ ।
२. छानामा प्रयोग हुने काठ साल, साज जस्ता कडा काठ हुनुपर्छ । यसलाई उपयुक्त रसायनले उपचार (treatment) गरेको हुनुपर्छ ।
३. छानामा लगाइएका सबै काठ एक अर्कामा राम्रोसँग जोडिएको हुनुपर्छ । भाटालाई डाँडासँग, डाँडालाई पर्खालको वालप्लेटसँग अनि वालप्लेटलाई खम्बासँग राम्ररी जोड्नुपर्छ ।
४. पाताका कोरोगेसनको डिलमा (उठेको भाग) 'जे' हुक अथवा ट्विस्टेड नेलले भाटासँग जोड्नुपर्छ । हावाले छानो उडाउन नपाओस् भन्नाका लागि छानाका छेउपट्टि अलि बाक्लोसँग जोड्नुपर्छ ।



चुच्ची भएको छानो

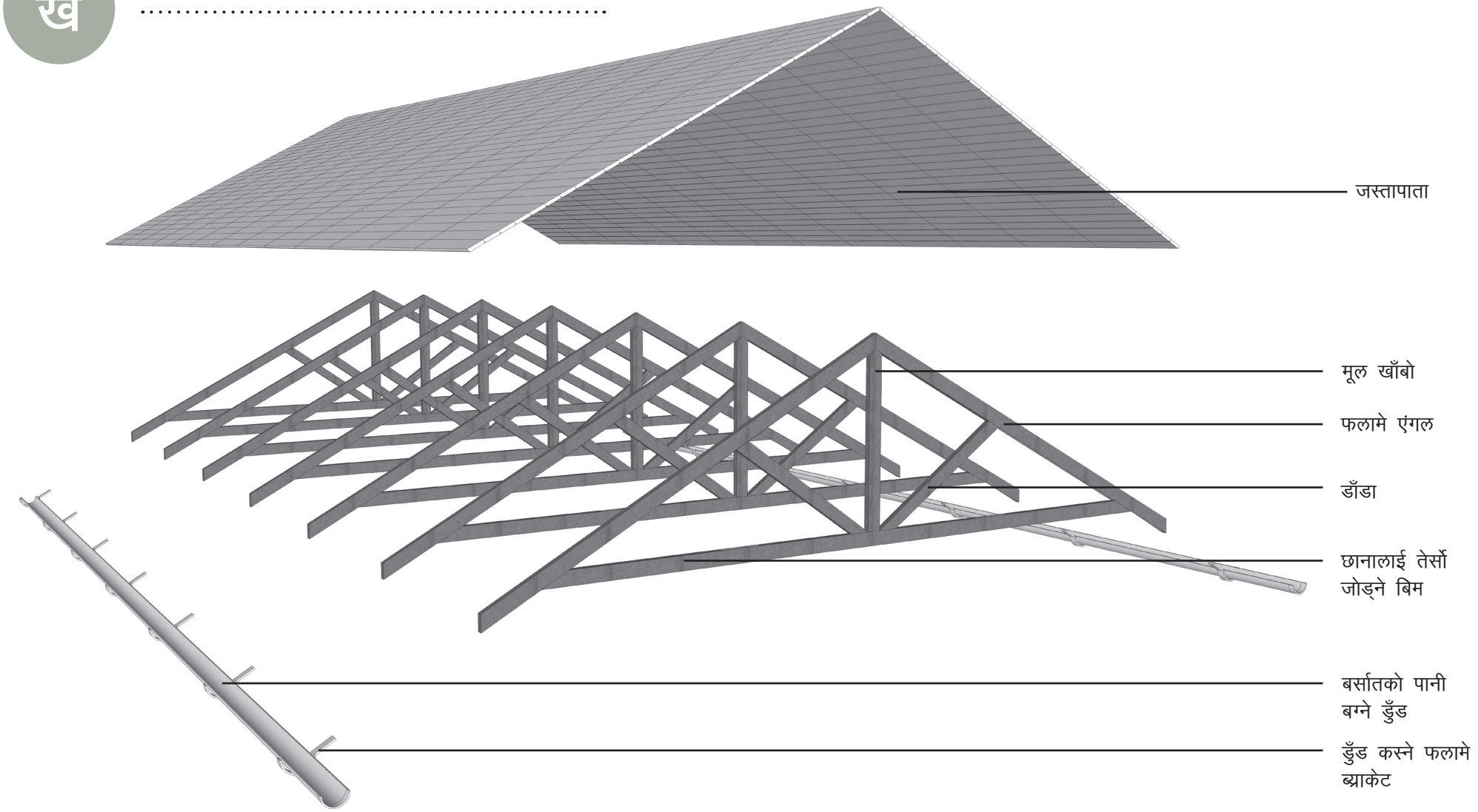

अनवरत (वारपार) धुरी
भाटा
डाँडा
थप भाटा
ढलानको भुइँ स्ल्याब
पर्खालबाट बाहिर निस्केको छानाको अधिकतम भाग (६० से.मि.)
दुईवटा खम्बाबीचको अधिकतम दूरी ३ मिटर

चारपाखे छानो


अनवरत (वारपार) धुरी
भाटा
डाँडा
थप भाटा
दुईवटा खम्बाबीचको अधिकतम दूरी ३ मिटर
ढलानको भुइँ स्ल्याब

ख

फलामे संरचना


जस्तापाता
मूल खाँबो
फलामे एंगल
डाँडा
छानालाई तेर्सो जोड्ने बिम
बर्सातको पानी बग्ने डुँड
डुँड कस्ने फलामे ब्राकेट