



Government of Nepal
National Reconstruction Authority

Workshop

International Conference on Nepal's Reconstruction NRA's Best Practices on Private Housing Retrofitting Experience and Way Forward

21st February 2021



Proceedings Report



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PREAMBLE

Retrofitting presents an ideal means for the conservation of traditional architectural heritage and provides the required space for beneficiaries to maintain their traditional agrarian lifestyle. Retrofitting not only saves hard earned capital but also mitigates earthquake risk.

A number of retrofitting related resource materials have been developed by the National Reconstruction Authority (NRA) and various partner organizations. The National Reconstruction Authority (NRA) has initiated documentation of these resource materials. It has also prepared roaster of trained human resources and recorded learnt lessons for charting out way forward.

The workshop on “NRA’s best practices on private housing retrofitting experiences and way forward” is one of the milestones. The workshop was organized with an objective of sharing key learnings and experiences on retrofitting of private houses carried out by the National Reconstruction Authority (NRA) and Partner Organizations. These learnings will be instrumental to develop strategic policies and plans. It will also help engineers and technical people to understand, replicate, refer to and develop different technologies that will ultimately support the homeowners to strengthen their houses as a preventive measure to reduce risk from future earthquake as well as recover from damage due to the recurring earthquakes.

We will persuade the generic line agencies and the local governments to initiate retrofitting programmes for the public buildings and private houses. We would be pleased if this proceedings report can be instrumental towards that direction.

Sushil Gyawali
Chief Executive Officer
National Reconstruction Authority



ACKNOWLEDGEMENT

The workshop on “NRA’s best practices on private housing retrofitting experiences and way forward” has been organized with a key objective to share key learnings and experiences on retrofitting of private houses carried out by the National Reconstruction Authority (NRA) and Partner Organizations. I would like to extend my sincere thanks to Central Level Project Implementation Unit (CLPIU) – Building, UNOPS, Build Change, UNDP, NSET, HRRP and CRS for their valuable contribution in developing the document as well as organizing the workshop.

I would also like to express my deepest gratitude to Executive Members of NRA, Prof. Prem Nath Maskey, Prof. Gokarna Bahadur Mothara, Mr. Tim Hart and Mr. Jitendra Bothara for their valuable inputs as commentators.

NRA CEO Mr. Sushil Gyawali deserves a special thanks for encouraging retrofitting of private houses. Without his leadership, this kind of solidarity and smooth operation of the activities and knowledge sharing would not have been possible.

Finally, I would like to thank all personnel involved, both directly and indirectly, for their valuable contribution in development of this strategy paper and Workshop Proceedings Report. I am confident that this document will be valuable to all the practitioners of Nepal’s retrofitting activities.

Maniram Gelal
Secretary
National Reconstruction Authority



FOREWORD

Almost 2.5 million houses in the 32 districts of Nepal have been affected by 2015 Gorkha earthquake. Out of them more than 78,000 have been categorized as retrofitting beneficiaries, however only 758 houses have been retrofitted so far. As NRA had to invest its entire energy in innovating cost effective technology, it could not adequately convince people for an early adoption.

Analysis suggests that there remain almost 3.5 million houses nationwide and up to 1.1 million houses within earthquake affected districts that require seismic retrofitting in some form. In this context, retrofitting presents a huge scope for mitigating risk of future disaster and post disaster recovery.

The presented papers outlined various retrofitting technologies such as strong back, splint and bandage jacketing, containment reinforcement integrated splint and bandage and retrofitting of timber houses. Each technology is supported by manual and guidelines. Having tested and proven method, these documents have created conducive ground for further replication. With further validation, the Ministry of Urban Development (MoUD) may consider to approving retrofitting norms which will pave the way for mass scale replication at least for the government buildings.

With empirically validated construction technologies, Nepal is appropriately placed to replicate at mass scale. However, this country has to work further for consolidation of the manual and generate awareness for enhancing acceptability of this technology. Not only the federal agencies but also the local governments have to be willing to implement this technology for public buildings, and private houses. This intervention will save initial investment and protect lives and properties.

We trust that this Workshop Proceedings Report will contribute significantly towards capturing as well as sharing valuable knowledge, learning and way forward towards replicating and scaling up NRA's best practices on private housing retrofitting in Nepal. Other countries may also benefit from our best practices.

Dr Chandra Bahadur Shrestha
Executive Member & ICNR Convener
National Reconstruction Authority



Abbreviations

BMC Brick Masonry in Cement Mortar

BMM Brick Masonry in Mud Mortar

CEO Chief Executive Officer

CLPIU Central Level Project Implementation Unit

CSEB Compressed Stabilized Earth Block

CRS Catholic Relief Services

Dr. Doctor

DG Director General

DUDBC Department of Urban Development and Building Code

HRRP Housing Reconstruction and Recovery Platform

ICNR International Conference on Nepal's Reconstruction

IOE Institute of Engineering

JICA Japan International Cooperation Agency

LNOB Leaving No One Behind

MoHA Ministry of Home Affairs

MoUD Ministry of Urban Development

NBC national Building Code

NRA National Reconstruction Authority

NSET National Society for Earthquake Technology



NDRRMA National Disaster Risk Reduction and Management Authority

TWG Technical Working Group

UNOPS United Nations Office for Project Services

UNDP United Nations Development Program

Workshop Agenda

Date: 21st February, 2021

Venue: Hotel Himalaya, Lalitpur

Time	Session	Facilitator
<u>Opening Session</u>		
9:00 – 9:15	Chairman: Mr. Shyam Kishor Singh, PD, CLPIU (Building), NRA Chief Guest: Mr. Sushil Gyewali, CEO, NRA Special Guests: Mr. Suresh Acharya, Secretary, NRA Dr. Chandra B. Shrestha, Executive Member & ICNR Convener, NRA Mr. Dhruba Prasad Sharma, Executive Member, NRA Dr. Bishnu Bhandari, Executive Member, NRA Dr. Hari Ram Parajuli, Executive Member, NRA Mr. Anil Pokhrel, EO, NDRRMA Mr. Navaraj Pyakurel, DG, DUDBC	
9:15-9:30	Objective and Overview of Workshop	Dr. Chandra B. Shrestha, Executive Member



<u>Technical Session</u>		
9:30 - 10:00	Presentation on “Strategic Paper on Private Housing Retrofitting”	Mr. Jhapper S. Vishokarma, CLPIU (Building) Ms. Pragya Pradhan, UNDP
10:00 - 10:30	Presentation on “Retrofitting Documents and Guidelines”	Mr. Bipin K Gautam, CLPIU (Building) Ms. Liva Shrestha, UNOPS Consortium
10:30 - 11:00	Presentation on “Norms and Standards on Retrofitting Works”	Mr. Ranjan Dhungel, NSET Mr. Deepak Saud, HRRP
11:00 - 11:30	Comments from Commentators	Dr. Hari Ram Parajuli Prof. Dr. Prem Nath Maskey Mr. Tim Hart Dr. Gokarna Motra Mr. Jitendra Bothara
11:30 - 12:15	Floor Discussion	
12:15 - 12:25	Remarks - Special Guest	Mr. Navaraj Pyakurel, DG, DUDBC
12:25 - 12:35	Remarks - Special Guest	Mr. Anil Pokhrel, EO, NDRRMA
12:35 - 12:45	Remarks - Special Guest	Mr. Suresh Acharya, Secretary, NRA
12:45 - 13:00	Remarks - Chief Guest	Mr. Sushil Gyewali, CEO, NRA
13:00 - 13:10	Remarks - Chairman	Mr. Shyam Kishor Singh, PD, CLPIU (Building)



Workshop Programme

Opening session:



Mr. Jhappar Singh Vishwokarma, Deputy Project Director from CLPIU (Building) welcomed all the participants to the workshop on “NRA’s best practices on private housing retrofitting experiences and way forward”. He informed that the workshop was both physical and virtual and that important personalities had connected and participated in the workshop. He then formally

commenced the opening session of the workshop at 9:00 AM (Nepal time) on February 21, 2021 at the Himalaya Hotel, Kathmandu, Nepal by requesting Mr. Shyam Kishor Singh, Project Director, CLPIU (Building), NRA to chair the program. Similarly, he requested Mr. Sushil Gyawali, Chief Executive Officer, NRA to take the seat as the Chief Guest of the program. He also requested special guests Mr. Suresh Acharya, Secretary, NRA, Dr. Chandra B. Shrestha, Executive Member & ICNR Convener, NRA, Mr. Dhruba Prasad Sharma, Executive Member, NRA, Dr. Bishnu Bhandari, Executive Member, NRA, Dr. Hari Ram Parajuli, Executive Member, NRA, Mr. Anil Pokhrel, EO, NDRRM, Mr. Navaraj Pyakurel, DG, DUDBC, representatives from development partners- UNOPS, Build Change, UNDP, NSET and all other participants to take their respective seats. He gave his sincere gratitude to all the commentators Dr. Hari Ram Parajuli, Prof. Dr. Prem Nath Maskey, Prof. Dr. Gokarna Bahadur Motra, Mr. Jitendra Bothara and Mr. Tim Hart for providing their valuable time and requested them to have their respective seats.

He then requested Dr. Chandra Bahadur Shrestha, Executive Member, NRA, to present the overview and objective of the workshop.



Dr. Chandra B. Shrestha said that it was an honor to welcome all in the hybrid workshop which had participation of many important personalities from both inside and outside the country.

He said that his presentation would have two parts- ICNR and retrofitting. He informed that nine programs had already been organized as part of ICNR and this workshop was its ninth program. He also highlighted on the planning for

publication of the learnings, and said that 23 publications would be published, including PDS Journal, proceedings reports, institutional profile, impact study, integrated settlement study, urban study and retrofitting documents.

He also gave an overview on the development of retrofitting including timeline on retrofitting of private housing. He informed that although more than 78000 houses have been categorized retrofit beneficiaries, only 758 houses had been retrofitted. Although it was not highly successful, he said that piloting of the process had been done successfully and these models could now be replicated. He also said that there is huge potentials of retrofitting. He further said that NRA would be contributing four documents in collaboration with prominent partners, such as UNOPS, Build Change, NSET and CRS, which would further help in replicating retrofitting throughout the country.

He informed that the workshop had been organized to share key learnings and experiences on retrofitting of private houses carried out by the Government of Nepal and Partner Organizations. These learnings will guide policy makers to make strategic policies and plans to take step toward making our communities, earthquake safe. It will also help engineers and technical people to understand, replicate, refer to and develop different technologies that will ultimately support the homeowners to strengthen their houses as a preventive measure to reduce risk from future earthquake as well as recover from damage due to the recurring earthquakes.

Finally, he pointed out some of the key expected outcomes after the successful completion of the workshop as:

- To initiate discourse on the urgency of retrofitting
- To undertake further research such as retrofitting for row housing
- Introduce policy reform of MoUD, NPC and local governments
- Initiate Functional banking system
- Preparation for the ICNR 2021
- To initiate a nationwide retrofitting campaign and interventions



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International Conference on Nepal's Reconstruction (ICNR
2021)

**NRA's Best Practices on Private Housing
Retrofitting Experience and Way Forward**

Dr. Chandra Shrestha – Executive Committee Member, NRA

**ICNR 2021 Updates and taking
forward the issue of retrofitting**



ICNR Updates

www.icnr.gov.np

www.icnr.gov.np/2021-conference/kathmandu/ Private Housing

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ICNR Timeline



National Housing Policy Authority

- First Meeting of Organizing Committee : 15 Nov. 2019,
- Thematic Workshops:
 - + a. Housing : 25-26, November 2019
 - + b. Heritage : 7-8, January 2020
 - + c. Infrastructure : 10-11, January 2020
 - + d. Livelihood: 13-14, January 2020
 - + e. Governance : 21-22, January 2020
- Symposium – scientific papers – Aug 24- 28, 2020
- Webinar for Compendium presentation: 27-28 Nov 2020
- **Workshop on Private Housing Retrofitting**
- Conference – 23-25 April 2021?

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ICNR Publications – 23 volumes

- Compendium – housing, heritage, public building, livelihood, governance, Part A (6 docs.)
- Seminar Proceeding Reports – 3
- Institutional profile - 1
- Open route document - 1
- PDS Journal – 2 volumes
- Vikash Journal – 3 volumes
- Impact Study – 1 volume
- Integrated settlement study – 1 volume
- Urban Study – 1 volume
- Retrofitting documents – 4 volumes

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On World Habitat Summit – Private housing

Retrofitting

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Retrofitting of Private housing: Timeline

- 2016 Dec. 29 - housing grant of NPR 200,000
- 24 June 2016 reclassified beneficiaries: Reconstruction (200k) and retrofitting (NPR 50k)
- 26 Dec. 2016 grant increased to NPR 300 k (Recons.) and NPR 100 k (retrofitting)
- 25 Sep. 2017 Repair & Retrofitting Manual
- March 2018 Light timber, steel frame structure manual published

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Status of Retrofitting of Private housing



- 78,033 retro category households 32 in districts
- 758 houses retrofitted
- What do these statistics speak?

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Potentials of retrofitting



- Household by foundation in 2011 census: Mud bonded (brick and stone) – 44% Mio; Cement bonded (brick/stone) – 18%; RCC with pillar – 10%; wooden pillar – 25%; others – 2% (Total – 5,423,297 households)
- 70% of 2015 EQ affected houses were stone masonry followed by abode
- Approximately 40% of housing stock may be still vulnerable to Earthquake setting aside other vulnerabilities which requires retrofitting intervention nationwide
- NRA could not deliver retrofitting as expected but created wealth of resources for replication

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Documentation



- NRA experience paper on private housing retrofitting
- Retrofitting documents and guidelines
- Norms and Standards for retrofitting construction works
- Roster of trained human resources on retrofitting

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Expected Outcomes

- To initiate discourse on the urgency of retrofitting
- To undertake further research such as retrofitting for row housing
- Introduce policy reform of MoUD, NPC and local governments
- Initiate Functional banking system
- Preparation for the ICNR 2021
- To initiate a nation wide retrofitting campaign and interventions!

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Technical Session:



Moderator of the technical session of the workshop, Dr. Ramesh Guragain, Deputy Executive Director, NSET, said that retrofitting has a huge potential in Nepal, and that there are many significant studies that indicate the importance of making buildings and infrastructures safe through retrofitting the existing buildings. He informed that there would be three presentations, followed by comment and feedback from leading

personalities from NRA, development partners, national and international experts. He also requested all the participants to write their valuable comments and questions in the chat box or paper (for those present physically), which could guide in further revising the document.



Presentation 1: Strategic paper on NRA's Best Practices on private housing; Retrofitting Experience and Way Forward by Mr. Jhappar Singh Vishwokarma, Deputy Project Director, CLPIU and Ms. Pragya Pradhan, UNDP



Mr. Jhappar Singh Vishwokarma's presentation focused on an overview and background on retrofitting approaches, design guidelines and manuals, community awareness and outreach, capacity building, retrofitting experiences in urban areas, learning and way forward.

He said that retrofitting has been relatively a small-scale intervention compared to new construction post 2015 earthquake. Some of the important initiatives that have paved the way for risk reduction and mitigation against future disaster include; a number of retrofitting resources have been developed by the government and various organizations and valuable learnings and documentations that guide any future implementations of retrofitting programs or initiatives.

He highlighted on the key elements of retrofitting as:

- The solutions are **easy to understand and replicate**
- Availability of **trained human resources** like masons and engineers
- The solutions are **affordable and culturally acceptable**
- **People centred approach - House owners sensitized to take action** to increase their seismic safety
- **Policy makers promote retrofitting** through technical and financial packages

He further informed that 758 houses have been retrofitted despite many limitations such as resource scarcity and geographical difficulties and that the valuable learnings from these experiences have been documented so that it will guide policy makers, implementers and development partners in future.



He also shed light upon various retrofitting approaches such as **Strong Back Technology** in which a **light CGI or timber gable** is provided with good connection to the roof and the ring beam and **improvements to the connections are made** with existing timber elements using CGI straps. He further informed that various public outreach and awareness efforts have been made through use of **videos** (14 videos - importance of retrofitting, shock table demonstration, initiating retrofitting, testimonials), **Public Service Announcements (PSAs)** (Short animated videos to give basic information on retrofitting - on what is retrofitting), **Booklets** (2 booklets - ten key points to remember during retrofitting and a visual technical guideline on repair, restoration and retrofitting), **Posters** (3 types for various target groups, raising mass awareness on both technical / financial aspects of retrofitting), **Flyers** (2 types for mass awareness on possibility to strengthen existing/damaged buildings and basic terminology of repair, restore and retrofitting) and **Mobile Applications** (For seismic assessment using artificial intelligence, that provide ideas on possibilities in strengthening the buildings to mitigate pre-existing vulnerabilities).

In terms of capacity building, 816 engineers and sub-engineers have been trained by partners through OJTs. 2604 engineers and sub-engineers have been trained on theoretical aspects of retrofitting and 2265 masons and artisans have been trained by partners.

The trainings are focused on:

- Basic concept of retrofitting
- Different types of retrofitting technologies
- Designing of retrofit solution for masonry structure
- Inspection of retrofitted houses
- Retrofitting included in on-boarding and refresher's trainings of all NRA engineers

Highlighting the major challenges and learnings, he pointed out that there is confusion between retrofit and repair among beneficiaries and there is no separate socio-technical assistance for retrofitting. Some of the other challenges include:

- Lack of risk awareness and need of retrofitting – use of old houses
- Willingness of retrofitting beneficiaries to transfer into reconstruction – 3 Lakh vs 1 Lakh
- Inadequate grant amount - grant driven rather than risk realization
- Lack of access for finance - Soft loans, collaterals
- Limited examples on retrofitting for public confidence building
- Misconception and rumors that retrofitting is - technically very difficult, not implementable
- Building code compliance vs. life safety – high upfront investment and low short-term return
- Limited viable technologies – dry stone masonry, row houses
- Lack of adequate quality materials – GI Wires



- Lack of required human resources/construction workforce to cater retrofitting needs – masons and engineers
- Lack of conducive policy environment for promoting retrofitting – socio-technical/financial packages

As a way forward, he emphasized on the need to conduct comprehensive awareness campaigns at all levels, ensure sensitization and building ownership among the stakeholders and create mobile technical teams to support upscaling at local level. He presented some of the key aspects to be considered for institutionalizing retrofitting, which can be discussed as:

- Policy makers take retrofitting as highly priority agenda for risk reduction
- Retrofitting to be included in engineering/vocational training curriculums/academia
- Retrofitting Approach, preventive measures, incremental retrofitting, levels of seismic safety to be highly prioritized
- Preparing ‘Ready to use designs’ for mass replication and upscaling
- Research on prevalent building typologies and the retrofitting solutions
- Institutionalization of trained human resources (engineers/ masons) by formation of retrofit cadre up to local level
- Improving supply chain and cost and assure quality of the construction materials

Finally, he shared that what NRA has learnt in the past five years by working with national and international communities has been remarkable, sharable and implementable. He also stressed on the need to document these learnings as well as take in valuable comments, suggestions and feedback from all to revise the document so that we could start working on how to address the issues of 6.4 million houses.




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Overview



- Background
- Retrofitting Approaches
- Design Guidelines and Manuals
- Public Outreach and Awareness
- Capacity Building
- Retrofitting in Urban Areas
- Challenges and Learnings
- Way forward

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Scenario

- About **78,033 households** identified under **retrofitting category** post 2015 EQ
- Old **'damaged'** houses are **still being used** besides the new house reconstructed with the Government grant
- **Large stock** of similar non-engineered **vulnerable houses** spread across Nepal

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Background

- Retrofitting - relatively **small-scale intervention** compared to new construction post 2015 earthquake
- Important initiatives that have **paved the way for risk reduction and mitigation** against future disaster
- A number of **retrofitting resources** has been developed by the government and various organizations
- There are **valuable learnings and documentations** that **guide** any future implementations of retrofitting programs or initiatives.

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Key Elements

Retrofitting program can only be successful if:

Key Actors



- The solutions are **easy to understand and replicate**
- Availability of **trained human resources** like masons and engineers
- The solutions are **affordable and culturally acceptable**
- **People centred approach** - House owners sensitized to **take action** to increase their seismic safety
- **Policy makers promote retrofitting** through technical and financial packages

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Retrofitting Approaches



Strong Back Technology

- A system of **reinforced concrete strong backs** placed at corners and at locations along the length of the wall, connected at the floor level by **slab strips and ring beam**
- The **through concrete** connects the inner and outer wythes of the thick walls preventing it from delamination
- A **cement sand plaster** is applied to the walls on the internal and external surfaces

It provides flexibility to retrofit buildings that fall beyond MRT. An alternative solution where S&B not viable

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Retrofitting Approaches



Strong Back Technology

- A light CGI or timber gable is provided with good connection to the roof and the ring beam
- Improvements to the connections with existing timber elements using CGI straps.

Technology	Average Cost (per m ²)
Strong Back	NPR 6,012

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Retrofitting Approaches



GI Welded Wire Mesh Splint and Bandage (with Local Failure Jacketing)

- A **foundation tie beam** is placed at prescribed location alongside all the walls
- The **vertical splints and horizontal bandages** are placed in respective locations on both sides of the walls
- To tie the wire mesh used in splints, bandages and jacketing, **anchorage** are placed at regular intervals
- **GI wire mesh is prepared on-site** to control local failure. Such a mesh is provided on all remaining parts of the walls

It enhances S&B technology's affordability at a reduced cost

Retrofitting Approaches

GI Welded Wire Mesh Splint and Bandage (with Local Failure Jacketing)



- After placement of all splints and bandages, **concrete is placed in the foundation tie beam.**
- The whole surface of the **wall is then plastered**
- A **light CGI or timber gable** is provided with good connection to the roof

Technology	Average Cost / m2
Splint & Bandage with WWM	NPR 7,700
Splint & Bandage with GI Wire Jacketing	NPR 5,562

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Retrofitting Approaches

Containment Reinforcement integrated Splint and Bandage



- **Horizontal bandages** secured on **both faces** of the wall with shear connectors and cross-links
- **Vertical splints** secured on all critical junctions starting from 450mm below plinth level upto the top of the wall at roof level
- Splint projected 150 mm at the bottom and **steel bar cage** is put over it with anchorage **followed by concreting**

It enhances S&B technology's affordability at a reduced cost of materials and workmanship

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Retrofitting Approaches



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Containment Reinforcement integrated Splint and Bandage

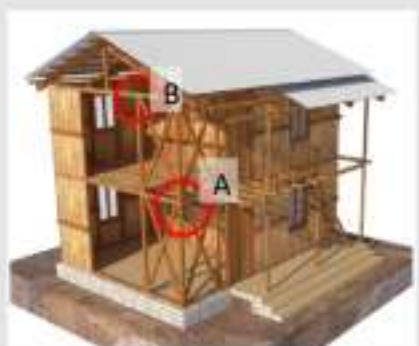
- The remaining walls are protected with **vertical and horizontal GI wires** in a grid with a distance of 16"
- **Flexible diaphragms** at floor and roof level ensured by connections between wall structure and roof structure
- The whole surface of the wall is then **plastered**
- A **light CGI or timber gable** is provided with good connection to the roof

Technology	Average Cost / m ²
CR integrated Splint and Bandage	NPR 3,640

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Retrofitting Approaches



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Timber house retrofitting

- Based on the requirements of **Light timber and steel structures manual** published by the Government of Nepal
- **Design a timber bracing scheme** including the lateral bracing capacity of masonry walls in case of with masonry wall
- Existing **timber connections** of the roof, the timber system and between two floors are **improved**
- **Stability of the masonry wall ensured** to prevent failure due to overturning

Technology	Average Cost / m ²
Timber	NPR 4,110
Timber with Masonry Ground floor	NPR 4,523

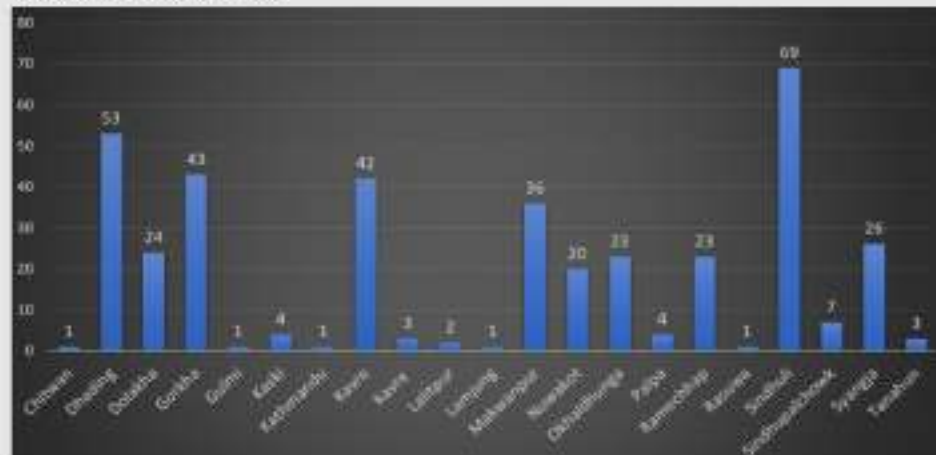
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Stocktaking

Retrofitted houses: 758



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Design Guidelines, Manuals, Standards



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Seismic Retrofitting Guidelines of Buildings in Nepal

Repair and Retrofit Manual for Masonry Structures

Repair and Retrofit manual for RCC structures

Engineering manual: Standard Type Design Retrofits of Stone

Masonry with Mud Mortar (SMM)

Norms for Rate Analysis of Retrofitting Masonry Building

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Public Outreach and Awareness

Videos: 14 videos - importance of retrofitting, shock table demonstration, initiating retrofitting, testimonials

Public Service Announcements: Short animated videos to give basic information on retrofitting - on what is retrofitting

Booklets: 2 booklets - ten key points to remember during retrofitting and a visual technical guideline on repair, restoration and retrofitting

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Public Outreach and Awareness



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Posters: 3 types for various target groups, raising mass awareness on both technical / financial aspects of retrofitting.

Flyers: 2 types for mass awareness on possibility to strengthen existing/damaged buildings and basic terminology of repair, restore and retrofitting.

App: For seismic assessment using artificial intelligence, that provide ideas on possibilities in strengthening the buildings to mitigate pre-existing vulnerabilities.

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Capacity Building

Total no. of Engineers and sub-engineers trained by partners through OJT= 816



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Capacity Building



Trainings on:

- Basic concept of retrofitting
- Different types of retrofitting technologies
- Designing of retrofit solution for masonry structure
- Inspection of retrofitted houses

Retrofitting included in on-boarding and refresher's trainings of all NRA engineers

Engineers and sub-engineers trained through OJT: 816

Engineers and sub-engineers trained (theoretical): 2604

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Masons and artisans trained by partners: 2265



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SN	Categories	Issues
1	Cost	In urban areas, RCC buildings are dominant and the retrofitting cost of RCC structure may be higher as compared to other structures
2	Technical manpower	There is a lack of skilled masons and technical person expertise on retrofitting. Limited structural engineers to analyze and design unique retrofit solutions.
3	Awareness	There is confusion between retrofit and repair among beneficiaries (52% have repaired). Willingness to demolish and reconstruct There is no separate socio-technical assistance for retrofitting.
4	Complexity	In core areas multiple storey load bearing structure in mud of more than 3 storey listed under retrofitting, feasibility needs to be critically assessed. Retrofitting of adjoined buildings is more complex and technically difficult
5	Compliance	Traditional building requires to be complaint with building code, byelaws of the municipality and department of Archeology



Challenges and Learnings



- Lack of risk awareness and need of retrofitting – use of old houses
- Willingness of retrofitting beneficiaries to transfer into reconstruction – 3 Lakh vs 1 Lakh
- Inadequate grant amount - grant driven rather than risk realization
- Lack of access for finance - Soft loans, collaterals
- Limited examples on retrofitting for public confidence building
- Misconception - technically very difficult, not implementable

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Challenges and Learnings

- Building code compliance vs. life safety – high upfront investment and low short-term return
- Limited viable technologies – dry stone masonry, row houses
- Lack of adequate quality materials – GI Wires
- Lack of required human resources/construction workforce to cater retrofitting needs – masons and engineers
- Lack of conducive policy environment for promoting retrofitting – socio-technical/financial packages

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Way Forward

- Comprehensive awareness campaigns at all levels
- Sensitization and building ownership of the stakeholders
- Policy makers take retrofitting as highly priority agenda for risk reduction
- Create mobile technical teams to support upscaling at local level
- Retrofitting included in engineering/vocational training curriculums

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Presentation 2: Retrofitting Documents and Guidelines by Mr. Bipin Kumar Gautam, CLPIU (Building) and Ms. Liva Shrestha from Build Change, UNOPS Consortium



Giving an overview on the retrofitting documents and guidelines, Mr. Bipin K. Gautam, Structural Engineer, CLPIU (Building) said that these guidelines and documents have been developed during the tenure of NRA in last 5 years

He also gave a brief summary on the retrofitting process implemented in 32 districts affected by 2015 Gorkha

Earthquake in Nepal. He further informed that although there are 78,033 retrofit beneficiaries, the numbers are reducing as more and more people are converting from retrofitting to reconstruction. He also explained that houses categorized as damage grade 2



and 3 were categorized as retrofit beneficiaries during the damage assessment carried out. Similarly, out of 78,033 retrofit beneficiaries, only 758 houses have been retrofitted so far in the post disaster period.

He reiterated that the main objective is to increase the capacity of buildings, not only for 2015 earthquake, but for the future earthquakes and that the guidelines help to increase the strength of buildings.

He presented some of the reasons and benefits of retrofitting as:

- Up-gradation of seismic design requirements
- Advancement of engineering knowledge
- Inconsistency between the design and actual construction at site
- Damage during past earthquake
- Guidelines will help to retrofit Vulnerabilities in existing undamaged buildings

Regarding retrofitting methods, he informed that there are basically two methods to retrofitting; 1. Reducing demand and 2. Increasing capacity, and that most of the buildings are retrofitted through increasing capacity. He further pointed out that the guidelines also focuses on the method of increasing capacity.

Highlighting the need for seismic retrofitting guidelines, he explained that there were very few documents while starting retrofitting, which included documents developed by DUDBC on Adobe, RCC, and masonry structures, which can be used by experienced engineers only. So he stressed on an urgent need to develop ready to use designs that can be scaled up widely.

He further pointed out some of the benefits of Ready-to-Use Retrofitting Manuals as:

- Quick and simple to use
- Provides a menu of solutions with different technologies
- Suitable when the demand for retrofitting solution/advice is large as in a post disaster context
- Suitable when homeowners cannot afford the services of experienced engineers to provide bespoke design in prevention context

Explaining about the general methodology for retrofitting, he explained that damage and vulnerability assessment is carried out in the beginning, and it is determined whether they are eligible for repair and retrofit or demolition and reconstruction based on the damage grade. Then, engineers check if the building is eligible to use this manual and if it is not eligible, then specific engineering analysis has to be used. If it is eligible, retrofitting process is carried ahead.

He also highlighted some of the features of retrofit manuals as:



- Supports engineers to provide quick and ready to use guidance on house retrofitting
- Describes vulnerability/deficiencies of masonry buildings
- Provides repair methods according to damage grade
- Describes retrofitting approaches to address the vulnerabilities
- Provides example designs for typical houses retrofitted with the approach for each manual
- Provides construction sequence to implement the retrofit approach

He also shed light upon some of the common retrofitting methods that have been implemented as:

- Splint and Bandage Technology
- Jacketing of Walls
- Strong Back Technology
- Splint and Bandage with CR Technology
- Strengthening of Timber building by Providing Bracing (around 100 timber buildings strengthened in last 4,5 years)

He also said that reducing vulnerability of buildings of masonry buildings is the main target, which could be achieved through

- Configuration and load path improvement
- Wall to wall connection improvement
- Wall to floor connection improvement
- Wall to roof connection improvement
- Diaphragm improvements
- Roof improvements
- Bracing parapet walls
- Securing gable walls
- Capacity improvement of structural walls

He further said that these different approaches have same target, that is to achieve life safety of buildings, and that the concern is how to use retrofitting in field. There are various retrofitting approaches and options that people can select from, therefore, it is termed as ready to use. The options include:

- Option 1: Retrofitting using RC splint-bandage and GI wires jacketing
- Option 2: Retrofitting using welded GI wire mesh Splint-bandage and GI wire jacketing
- Option 3: Retrofitting using welded GI wire mesh Splint-bandage and PP band jacketing
- Option 4: Retrofitting using wooden Splint-bandage and GI wires jacketing

However there are certain limitations such as:



- Applicable to buildings that fall under Category 'C' and 'D' as per NBC
- Applicable to definite architectural and structural configuration
- Mainly based on Splint and bandage/ Jacketing approach

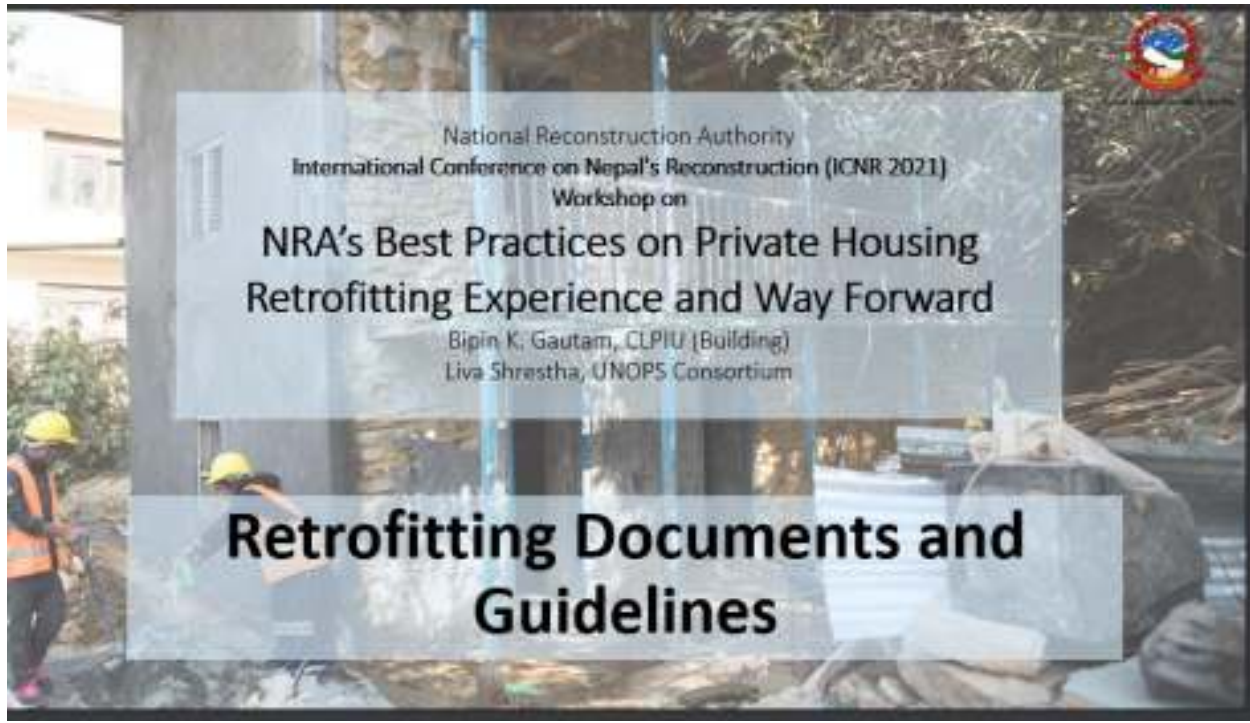
He also provided key insights on the Manual for Strong Back Retrofit Approach as:

- Manual based on NRA and CLPIU approved Retrofitting type design using strong back approach
- Caters to SMM houses that meets a given set of applicability criteria
- Provides alternative details based on some field variations
- The type designs has been derived based on many iterations for different opening percentage in walls, width of piers, size of building
- Various critical structural conditions were considered for design iteration

He further explained that the benefit of this manual is that it addresses limitations related to cross walls to some extent and gives house owners options to use RCC or timber. It is also cost effective and has introduced the concept of incremental retrofitting, that is, retrofitting main vulnerable areas first, and adding retrofitting to other less vulnerable elements later.

Giving an explanation on why we need a consolidated retrofit manual, he said that the demand of safety is increasing and since the seismic code of Nepal is revised, revisit of manual is required to meet the desire of increasing safety levels. He further said that there are different manuals with different safety measures; if they are all consolidated then it would be easier for engineers to choose from the many options. Likewise, different technologies have their own benefits and limitations; so a consolidated manual helps technical people for better selection among alternative technologies. He also informed that different technologies were implemented during post disaster after approval from the government bodies and large scale human resources were trained in different technologies.

As a way forward, he stressed on the need for a consolidated manual that considers all implemented alternative technologies. He also emphasized on the need to ensure use of large scale trained human resource on each technology outside 32 districts and minimization of engineering costs by promoting easy to use and easy to check guidelines. Finally he said that replication of implemented retrofitting technologies should be carried all over the country because more than 3.2 million buildings are still vulnerable and this is the best time to address the need for safety of buildings from future earthquakes.

A background image showing construction workers in yellow hard hats and orange safety vests working on a building site.

National Reconstruction Authority
International Conference on Nepal's Reconstruction (ICNR 2021)
Workshop on

NRA's Best Practices on Private Housing Retrofitting Experience and Way Forward

Bipin K. Gautam, CLPIU (Building)
Liva Shrestha, UNOPS Consortium

Retrofitting Documents and Guidelines

Overview



- 32 districts affected by 2015 Gorkha Earthquake
- 78,033 retrofit beneficiaries
- Houses that are categorized as damage grade 2 and damage grade 3
- 758 houses retrofitted Post Disaster

Repair/Retrofitting



Repair

- Does not improve the structural strength of the building
- Structure does not meet strength requirements for the next earthquake

Retrofitting

- Removes seismic deficiencies and improves the response of existing buildings

Reasons for Retrofitting



- Up-gradation of seismic design requirements
- Advancement of engineering knowledge
- Inconsistency between the design and actual construction at site
- Damage during past earthquake
- Vulnerabilities in existing undamaged buildings



Retrofitting Methods

Reducing Demand

- Use of supplemental damping
- Reduction of mass
- Isolate existing structure

Increasing Capacity

- Stiffen existing structure
- Strengthen existing structure
- Enhance Ductility
- Reduce Irregularity

We mostly retrofitted by increasing capacity of the existing structure

Seismic Retrofitting Guidelines



- Supports engineers in design of retrofits
- Takes engineering time and effort to design a retrofit
- Requires experienced engineer to design retrofit using the guidelines
- The guideline can be used to support calculations required for producing easy to use guidelines and manuals



Ready-to-Use Retrofitting Manuals



- Quick and simple to use
- Provides a menu of solutions with different technologies
- Suitable when the demand for retrofitting solution/advice is large as in a post disaster context
- Suitable when homeowners cannot afford the services of experienced engineers to provide bespoke design in prevention context

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Other Relevant Documents



- **Correction/Exception Manual:** Manual addressed the problems in the reconstructed houses after Gorkha Earthquake and their remedial solutions
- **Light Timber/ Steel Frame Structure Manual:** Manual provides simplified calculations and correction of different types of timber building

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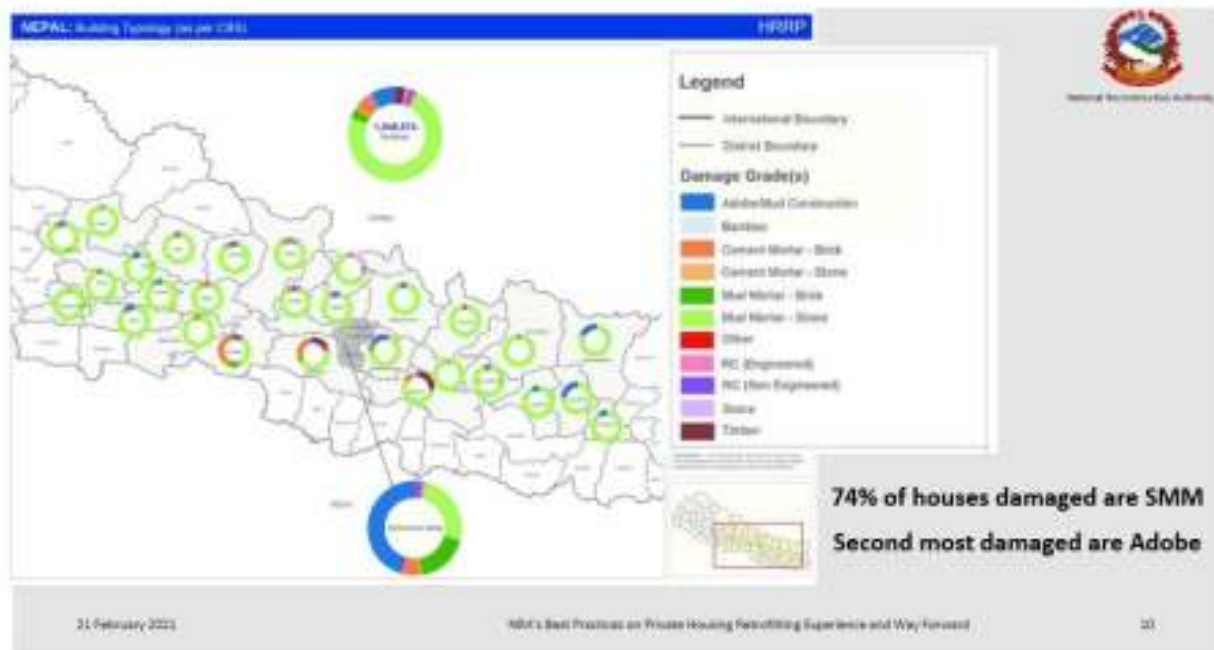
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General Methodology



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NDRF's Best Practices on Private Housing Retrofitting Experience and Way Forward



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NDRF's Best Practices on Private Housing Retrofitting Experience and Way Forward

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Features of Retrofit Manuals



- Supports engineers to provide quick and ready to use guidance on house retrofitting
- Describes vulnerability/deficiencies of masonry buildings
- Provides repair methods according to damage grade
- Describes retrofitting approaches to address the vulnerabilities
- Provides example designs for typical houses retrofitted with the approach for each manual
- Provides construction sequence to implement the retrofit approach

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Vulnerability/Deficiencies of Masonry Buildings



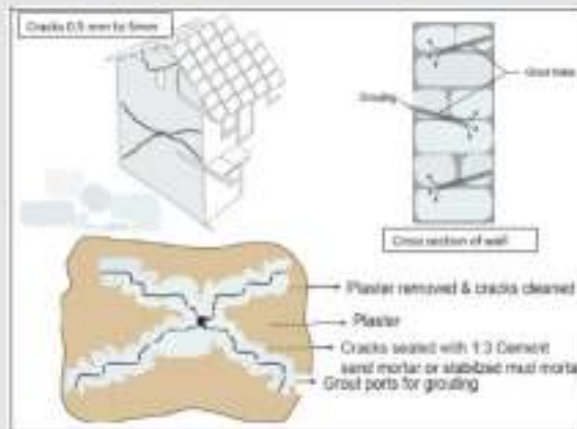
- Gable wall collapse
- Out of plane failure of transverse walls
- Bulging or separation of stone Wythes in thick walls
- Corner separation
- Floor collapse

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Repair/ Restore Methods



- Explains about the material and equipment used for repairing
- Methodology of repairing of different types of cracks and damage of walls

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WHA's Best Practices on Private Housing Retrofitting Experience and Way Forward

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Common Retrofitting Methods we Implemented



- Splint and Bandage Technology
- Jacketing of Walls
- Strong Back Technology
- Splint and Bandage with CR Technology
- Strengthening of Timber building by Providing Bracing

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WHA's Best Practices on Private Housing Retrofitting Experience and Way Forward

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Common Retrofitting interventions



Different approaches to achieve same target

- Configuration and load path improvement
- Wall to wall connection improvement
- Wall to floor connection improvement
- Wall to roof connection improvement
- Diaphragm improvements
- Roof improvements
- Bracing parapet walls
- Securing gable walls
- Capacity improvement of structural walls

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NIDM's Best Practices on Private Housing Retrofitting Experience and Way Forward

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Repair and Retrofitting Manual for Masonry Structures



Contents

- Part A: Seismic Damage and Intervention
- Part B: Seismic Deficiencies and interventions
- Part C: Ready to use seismic retrofit designs
- Part D: Construction sequences

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NIDM's Best Practices on Private Housing Retrofitting Experience and Way Forward

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Repair and Retrofitting Manual for Masonry Structures



Splint and Bandage approach basic elements

- Vertical reinforcement bands at corners, intersections and at openings called splint
- Horizontal reinforcement band at sill, lintel and floor levels called bandage
- Jacketing at spaces between the splint and bandage

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NHA's Best Practices on Private Housing Retrofitting Experience and Way Forward

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Repair and Retrofitting Manual for Masonry Structures



Table 11: Minimum grade - M40 concrete splint and bandage (for masonry)									
No.	No. of joints	Max. no. of joints	Concrete grade (M40)	Min. 100mm	Min. 100mm	Min. 100mm	Min. 100mm	Min. 100mm	Min. 100mm
1	1	1	M40	100	100	100	100	100	100
2	2	2	M40	100	100	100	100	100	100
3	3	3	M40	100	100	100	100	100	100
4	4	4	M40	100	100	100	100	100	100
5	5	5	M40	100	100	100	100	100	100
6	6	6	M40	100	100	100	100	100	100
7	7	7	M40	100	100	100	100	100	100
8	8	8	M40	100	100	100	100	100	100
9	9	9	M40	100	100	100	100	100	100
10	10	10	M40	100	100	100	100	100	100

Note: 1. The minimum grade - M40 concrete splint and bandage (for masonry) shall be of 300mm x 300mm x 300mm and 300mm x 300mm x 300mm and all other dimensions shall be as per the design. 2. The minimum grade - M40 concrete splint and bandage (for masonry) shall be of 300mm x 300mm x 300mm and 300mm x 300mm x 300mm and all other dimensions shall be as per the design. 3. The minimum grade - M40 concrete splint and bandage (for masonry) shall be of 300mm x 300mm x 300mm and 300mm x 300mm x 300mm and all other dimensions shall be as per the design. 4. The minimum grade - M40 concrete splint and bandage (for masonry) shall be of 300mm x 300mm x 300mm and 300mm x 300mm x 300mm and all other dimensions shall be as per the design. 5. The minimum grade - M40 concrete splint and bandage (for masonry) shall be of 300mm x 300mm x 300mm and 300mm x 300mm x 300mm and all other dimensions shall be as per the design. 6. The minimum grade - M40 concrete splint and bandage (for masonry) shall be of 300mm x 300mm x 300mm and 300mm x 300mm x 300mm and all other dimensions shall be as per the design. 7. The minimum grade - M40 concrete splint and bandage (for masonry) shall be of 300mm x 300mm x 300mm and 300mm x 300mm x 300mm and all other dimensions shall be as per the design. 8. The minimum grade - M40 concrete splint and bandage (for masonry) shall be of 300mm x 300mm x 300mm and 300mm x 300mm x 300mm and all other dimensions shall be as per the design. 9. The minimum grade - M40 concrete splint and bandage (for masonry) shall be of 300mm x 300mm x 300mm and 300mm x 300mm x 300mm and all other dimensions shall be as per the design. 10. The minimum grade - M40 concrete splint and bandage (for masonry) shall be of 300mm x 300mm x 300mm and 300mm x 300mm x 300mm and all other dimensions shall be as per the design.

Major Retrofitting approaches

- Option 1: Retrofitting using RC splint-bandage and GI wires jacketing.
- Option 2: Retrofitting using welded GI wire mesh Splint-bandage and GI wire jacketing
- Option 3: Retrofitting using welded GI wire mesh Splint-bandage and PP band jacketing
- Option 4: Retrofitting using wooden Splint-bandage and GI wires jacketing.

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Repair and Retrofitting Manual for Masonry Structures



- Applicable to buildings that fall under Category 'C' and 'D' as per NBC
- Applicable to definite **architectural and structural configuration**
- Mainly based on Splint and bandage/ Jacketing approach

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Manual for Strong Back Retrofit Approach



- Manual based on NRA and CLPIU approved Retrofitting type design using strong back approach
- Caters to SMM houses that meets a given set of applicability criteria
- Provides alternative details based on some field variations
- The type designs has been derived based on many iterations for different opening percentage in walls, width of piers, size of building
- Various critical structural conditions were considered for design iteration

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Manual for Strong Back Retrofit Approach



Building length (meters)	Building width (meters)	Minimum pier length, P, required (meters)			
		Longitudinal walls		Transverse walls	
		Door-to-window	Window-to-window	Door-to-window	Window-to-window
8.5 ≤ L < 10.7	4.5 ≤ B < 5	0.925	0.6	1.6	1
	5 ≤ B ≤ 6			1.35	0.95

Manual for Strong back Retrofit Approach



Through concretes



Ring beam



Strong backs



Slab strips

Plaster on both sides of the wall

Welded wire mesh jacket for slender wall piers



Manual for Strong back Retrofit Approach

Location in plan	Material	Minimum size of cross section	Allowable max spacing (center-to-center)	Notes
Corners	Reinforced concrete	200 mm x 200 mm (8"x8")	N/A	
Along longitudinal walls	Reinforced concrete	200 mm x 200 mm (8"x8")	2800 mm (9.2 ft)	Shall be at least 150 mm from edge of opening.
Midpoint of transverse wall (2 locations)	Timber	Per timber strongback table	N/A	Acceptable to reuse existing posts that meet minimum dimensions and are in good condition

- Option of timber and reinforced concrete strong backs

Strongback timber type	Transverse wall length, ℓ	Minimum cross section dimensions (see Note)
Soft timbers	$8 \leq \ell < 16$ m	150 mm x 150 mm (6"x6")
	$16 \leq \ell < 30$ m	200 mm x 200 mm (8"x8")

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Field Guide for Repair and Retrofitting



- Splint and bandage approach used
- Splint and bandage of welded wire mesh
- Horizontal and vertical containment reinforcement wires
- Diagonal ties/bracings under floor with GI wires

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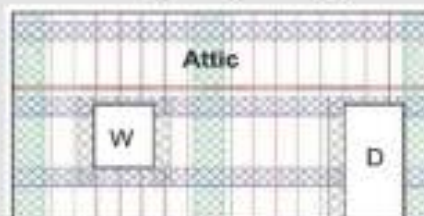
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Field Guide for Repair and Retrofitting



- Due to minimum use of the GI containment wires in less stress area results in economical solution.
- Concept of Incremental retrofitting/ Phase retrofitting within the building- budget management



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Consolidated form of Retrofit Manual

Since the seismic code of Nepal is revised, revisit of manual is required

- Different Technologies have their own benefits and limitations, Help technical people for better selection among alternative technologies
- Similar contents in all manuals only different approach
- Different Technologies implemented during post disaster after approval from the Government Body
- Large Scale human resources were trained in different technologies

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National Reconstruction Authority

Way Forward



- Consolidated manual considering all implemented alternative technologies is necessary
- Use of Large Scale Trained Human Resource on each Technology outside 32 districts
- For scale up, engineering costs need to be minimized by promoting easy to use and easy to check guidelines
- Replication of implemented retrofitting technologies over the country

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Presentation 3: Norms and Standards of Retrofitting Works by Mr. Ranjan Dhungel, NSET and Mr. Deepak Saud, HRRP



Mr. Deepak Saud, HRRP highlighted on the norms for rate analysis of retrofitting masonry buildings, which was developed by Retrofitting Technical Working Group in March 2020. He also shed light upon the key aspects of human resource and quantity of material required for retrofitting works. His presentation focused on the brief



overview of manual, its development process, steps in consolidation process, limitations of norm, major items included in norms and the way forward.

He presented lack of documents for retrofitting as one of the key challenges for retrofitting of buildings, saying that many documents were developed only after Gorkha earthquake, particularly in 2017. As a result engineers and mid-level construction masons found it difficult to estimate the cost of retrofitting. Therefore, he pointed out that the main objective of developing the norms for rate analysis for masonry buildings was to support retrofitting cost analysis of masonry buildings.

Explaining the development process, he said that a Technical Working Group (TWG), under HRRP Platform, was formed to consolidate and develop various documents and resource materials. One of its key tasks was to standardize norms for retrofitting of masonry buildings. The TWG consisted of engineers from UNDP, HRRP, NSET, Build Change and CRS.

He also summarized the steps in consolidation process as:

- Collection and compilation of norms and rate analysis used by different organizations
- Discussion and consensus on the various line items pertaining to retrofitting
- Collection and compilation of actual human resource used for different specialized tasks in retrofitting from several sample retrofit sites
- Averaging of rates (human resources, materials) based on actual field scenario
- Development of revision of norms and rates where applicable

He further highlighted on the validation process & norms formation and said that around 80 sites were examined, and data on human resources & materials were recorded precisely by NSET, Build Change and UNDP. He also informed that some parts of the norms are taken from the Government's new construction norms.

Some of the major items included in the norms are:

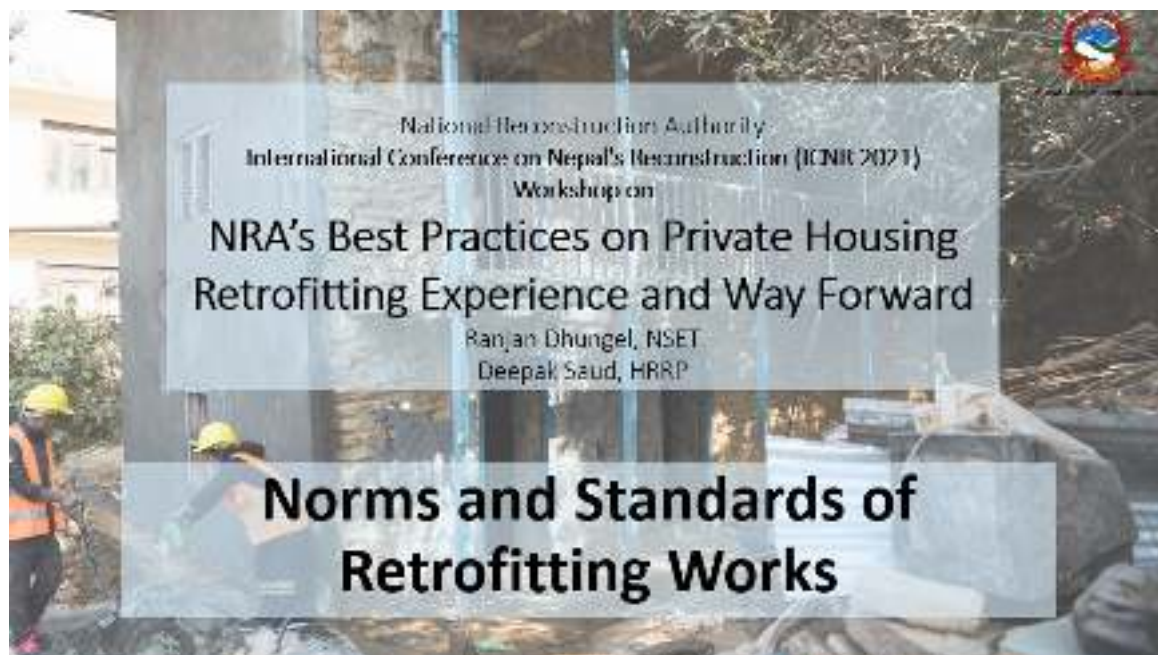
- Site Clearance and Protection Works
- Excavation and Backfilling
- Shoring works
- Masonry works
- Concrete & Rebar Works
- Formwork
- Wire mesh Works
- Plaster Works
- Containment/Jacketing
- Anchorage Works
- Through Concrete, Dowel Works and Timber Splicing
- Replacement of Heavy Gable with Light Material
- Roof and connection Improvement



He explained the site clearance and protection works as:

- Providing and fixing the 500-gauge polythene sheet
- Removing of existing doors and windows shutter and its fixture
- Demolition of wall BMC and storage within haulage of 10m
- Demolition of existing PCC flooring
- Stripping and Raking of Existing mud plaster from SMM/BMM
- Stripping of Existing Cement plaster SMC/BMC

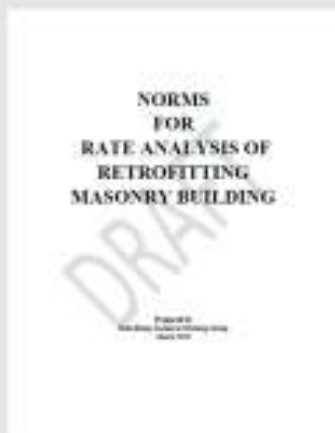
As a way forward, he emphasized on the need to carry out field validation by sending the norms for rate analysis to field engineers and mid-level construction technicians so that they can use it for estimation in the field. He also stressed on the need for government approval for its wider implementation. Finally, he said that the capacity of engineers and mid-level construction technicians need to be developed for implementation of the norms for rate analysis.





National Infrastructure Authority

Overview



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Background & Objective

Development Process

Steps in Consolidation Process

Scope and Basis

Major Items

Way forward

NIA's Best Practices on Private Housing Retrofitting

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National Infrastructure Authority

Background & Objective



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- 78,033 retrofitting beneficiaries
- Cost is key aspect for retrofitting intervention
- Developed to support the retrofitting cost analysis of masonry structures

NIA's Best Practices on Private Housing Retrofitting

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National Housing and Infrastructure Authority

Development Process



- Under HRRP Platform, a Technical Working Group (TWG) was formed to consolidate and develop various documents and resource materials
- One of the key task: to standardize norms for retrofitting of masonry buildings
- The TWG consisted of engineers from UNDP, HRRP, NSET, Build Change and CRS

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NHIA's Best Practices on Private Housing Retrofitting

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National Housing and Infrastructure Authority

Steps in Consolidation Process



- Collection and compilation of norms and rate analysis used by different organizations
- Discussion and consensus on the various line items pertaining to retrofitting
- Collection and compilation of actual human resource used for different specialized tasks in retrofitting from several sample retrofit sites
- Averaging of rates (human resources, materials) based on actual field scenario
- Development of revision of norms and rates where applicable

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NHIA's Best Practices on Private Housing Retrofitting

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National Reconstruction Authority



Scope and Basis

- It covers stone and brick masonry buildings (both with mud and cement mortar)
- Retrofitting Techniques
 - splint and bandage
 - containment reinforcement (CR) system /local failure jacketing
 - strong-back method
- Results are based upon observation from partner organizations and some components have adopted from standard governmental norms for new construction

NRA's Best Practices on Private Housing Retrofitting

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National Reconstruction Authority

Validation Process & Norms Formation



- Around 80 sites were examined, and data on manpower & material recorded precisely by NSET, Build Change and UNDP
- Some parts of the norms are taken from the Government's new construction norms

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NRA's Best Practices on Private Housing Retrofitting

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National Reconstruction Authority

Major Items



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1. Site Clearance and Protection Works
2. Excavation and Backfilling
3. Shoring works
4. Masonry works
5. Concrete & Rebar Works
6. Formwork
7. Wire mesh Works
8. Plaster Works
9. Containment/Jacketing
10. Anchorage Works
11. Through Concrete, Dowel Works and Timber Splicing
12. Replacement of Heavy Gable with Light Material
13. Roof and connection Improvement

NRA'S BEST PRACTICES ON PRIVATE HOUSING RECONSTRUCTION

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National Reconstruction Authority

Site Clearance and Protection Works



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- Providing and fixing the 500-gauge polythene sheet
- Removing of existing doors and windows shutter and its fixture
- Demolition of wall BMC and storage within haulage of 10m
- Demolition of existing PCC flooring
- Stripping and Raking of Existing mud plaster from SMM/BMM
- Stripping of Existing Cement plaster SMC/BMC

NRA'S BEST PRACTICES ON PRIVATE HOUSING RECONSTRUCTION

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Site Clearance and Protection Works



Stripping and Raking of Existing mud plaster from SMM/BMM

Rate Analysis for 1 sq.m

Resources	Particulars	Unit	Quantity
human resource for scrapping	Unskilled	Md	0.06
human resource for raking & cleaning	Unskilled	Md	0.06
Damage recovery (30%)			
Tools (3% labor)			

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INDIA'S BEST PRACTICES IN PRIVATE INFRASTRUCTURE DEVELOPMENT

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Wire mesh Works



- Cutting and laying SWG10 welded wire mesh (50mm X 50mm)
- Cutting and laying SWG10 welded wire mesh (25mm X 25mm)
- Cutting and laying SWG12 welded wire mesh (50mm X 50mm)
- Cutting and laying SWG14 welded wire mesh (31mm X 31 mm)
- Cutting and laying SWG12 welded wire mesh (25mm X 25 mm)
- Cutting and laying SWG15 welded wire mesh (20mm X 20mm)

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INDIA'S BEST PRACTICES IN PRIVATE INFRASTRUCTURE DEVELOPMENT

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Wire mesh Works



Cutting and laying SWG10 welded wire mesh and mesh size 50mm X 50mm

Rate Analysis for 1 sq.m

Elements	Particulars	Unit	Quantity
human resource	Skilled	Md	0.09
	Unskilled	Md	0.12
Material	Wire mesh	sq.m	1.1
Tools (3% labor)			

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MA's Best Practices on Private Housing Retrofitting

22

Plaster Works



- Cement plaster works over on walls, with cement sand mix (1:4) and 12.5 mm thick
- Cement plaster works over GI wire mesh / chicken wire mesh on Stone Masonry walls, with cement sand mix (1:3) and 30 mm thick
- Cement plaster works over GI wire mesh / chicken wire mesh on Stone Masonry walls, with cement sand mix (1:3) and 20 mm thick
- Cement plaster works over GI wire mesh / chicken wire mesh on Stone masonry walls, with cement sand mix (1:3) and 35 mm thick
- Cement plaster works over GI wire mesh / chicken wire mesh on Stone masonry walls, with cement sand mix (1:3) and 40 mm thick

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MA's Best Practices on Private Housing Retrofitting

23

Plaster Works

Cement plaster works over GI wire mesh / chicken wire mesh on Brick walls, with cement sand mix (1:3) and 30 mm thick

Rate Analysis for 100 sq.m



Resources	Particulars	Unit	Quantity
human resource	Skilled	Md	16
	Unskilled	Md	16
Material	Cement	bags	30
	Sand	cum	3
Tools (3% labor)			

Containment/Jacketing



- Providing 12G GI Wire @ 100mm c/c
- Fixing 4mm dia. GI wire in specified location attached with each cross-link hook placed at specified interval

Containment/Jacketing

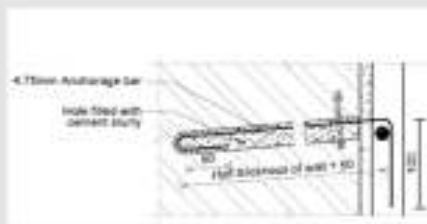


Providing 12G GI Wire @ 100mm c/c for prevention of local failure

Rate Analysis for 1 sq.m area

Resources	Particulars	Unit	Quantity
human resource	Skilled	Md	0.06
	Unskilled	Md	0.06
Material	12G GI Wire	kg	1.012
Tools (3% labor)			

Anchorage Works



- Throughout anchoring of SWG 10 (3.15) mm wire at 600 mm c/c with staggered layout for connection of jacketing mesh on both sides of wall
- Anchorage of 4.75 mm bar with staggered layout at 600 mm c/c for connecting splints and bandages on both sides of wall
- Cast In-situ Concrete Shear Connector for all belts in 450 mm thick wall with 8mm TOR rod and infill of Concrete 1:2:4

Anchorage Works



Throughout anchoring of SWG 10 (3.15) mm wire at 600 mm c/c with staggered layout for connection of jacketing mesh on both sides of wall

Rate Analysis for 1 nos.

Resources	Particulars	Unit	Quantity
human resource	Skilled	MO	0.017
	Unskilled	MO	0.017
Materials	SWG 10(3.15) mm wire	kg	0.09
Tools	Drilling Machine		
	Drill bit		

Through Concrete, Dowel Works and Timber Splicing



- Providing 150mm thick and 450mm deep Through concrete
- Providing 150mm thick and 450mm long Dowel
- Providing the Timber Splicing

Through Concrete, Dowel Works and Timber Splicing

150mm thick and 450mm deep Through concrete placed in existing wall to prevent wall delamination

Rate Analysis for 10 nos.



Itemization	Particulars	Unit	Quantity
Material	Skilled	Md	0.5
	Unskilled	Md	2.5
Material	Cement	bags	0.7
	Sand	cum	0.04
	Aggregate	cum	0.08
	Rebar (Iron)	kg	2

Roof and Connection Improvement



- Connection of Rafter and Purlin
- Connection of sill plate with ring beam
- Connection of Ridge Beam and Timber Post



National Housing Authority

Roof and Connection Improvement



Connection of rafter and purlin with 12G GI Wire

Rate Analysis for 40 connections.

Resources	Particulars	Unit	Quantity
human resource	Unskilled	Md	1
Material	12G GI Wires	kg	1.2
Tools (3% labor)			

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NHA's Best Practices on Private Housing Retrofitting

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National Housing Authority

Way Forward



- Field validation
- Government approval process
- Implementation

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Remarks from Commentators

Remarks from Dr. Hari Ram Parajuli, Executive member of NRA and Chair of Technical Team



Dr, Hari Ram Parajuli said that the draft document was good but requires some finishing works. Going back to the beginning of the process, he said that the work on developing guidelines on retrofitting had started since 2017 with support from various institutions and individuals including NSET, JICA, World Bank, Prof. Maskey, Dr. Motra respectively, and NRA led the whole process. He further

requested all to refer to the document and suggested that the write up should not be copy and pasted, with proper credit given or sources mentioned where required. He also requested Dr. Chandra to include some retrofitting success stories on Singha Durbar and Durbar School in the publication, saying that it should not be limited to private housing only and should include the retrofitting of public buildings also. He even requested to use the term “methods and approaches” rather than “strategy” for the document. He informed that all the technical issues in the draft had been noted down and would be shared directly instead of sharing in the public platform. He also requested to have a chapter on Approaches and Methods, which would specify on the kind of strategy used in terms of reducing demand or increasing capacity. Similarly, he suggested to include calculations and document the guideline properly as a lot of time and resources had been invested and on it. Lastly, he appreciated the team for using norms and standards in retrofitting. Finally, he urged everyone to work together in making the document more clear and include all items, saying that it would be a valuable resource for future if rate analysis is used properly.



Remarks from Prof. Prem Maskey, Institute of Engineering



Prof. Maskey appreciated the efforts and thanked all the individuals concerned in developing the document. He also pointed out some of the deficiencies with an objective to improve the document. He basically highlighted on three major issues: 1. Need for classifying the building typology and making it be known to others: He said that as the document focusses on non-engineering structures in

reinforced masonry, it is important to classify them. He further said that engineers have to guide the society in interpreting the engineering knowledge, which requires a lot of research in masonry. He even said that masonry cannot be avoided in the next 50 to 80 years. He also pointed towards the need to introduce alternatives to masonry, and that NRA, CLPIU and DUDBC have already done that. He said that it was high time to go for green materials, such as earth bags, hollow concrete blocks, CSEB, confined masonry or other materials that are specific to our context 2. Need to carry out structural conditions assessment and publish it: He stressed on the need to determine seismic vulnerability before and after retrofitting. He further said that retrofitting has been done in such a way that there is hardly any difference among repair, retrofitting and reconstruction; therefore there is a need to improve that. He suggested to clarify the distinction between repair and retrofitting in all guidelines, documents or manuals, and 3. Need to ensure periodic maintenance of materials: Giving examples of heritage structures, he said that since heritage buildings are very prone to deterioration, their regular maintenance should be introduced in retrofitting too, then only it can be a success.



Remarks from Dr. Gokarna Motra, IoE



Dr. Motra said that although the document was very good, there is a need to fill some voids. Giving his technical feedback, he said that the introduction part, although well-written, needs to specify the audience for whom it is written. Is it for written for engineers or practitioners or masons? If it is intended for engineers or designers, there is a need to add some technical words, describe some common failure mechanisms and include

observations from 2015 Gorkha earthquake. If it is intended for professionals, it is necessary to include how **in-plane and out-of-plane** types of deficiencies will be addressed. Similarly, he said that strong back technologies had been well introduced, however stitch had been missing in splint and bandage, so there is a need to clarify that. Likewise, he suggested to add a brief description on push over curve and on brick masonry typologies in building typologies. He advised to add a justification on variation of costs and address how to preserve timber in masonry buildings. Finally, he suggested to advocate for incremental retrofitting by identifying and addressing major deficiencies in private houses, and stressed that this document would be even more valuable if validation of what has been done so far could be added.



Remarks from Tim Hart, Build Change

Mr. Tim Hart thanked everyone for participating in presenting the document and present his six major observations; 1. Scope of retrofitting and guidelines: He pointed out towards the need to add retrofitting of RCC houses too, since such buildings had been significantly damaged in Sindhupalchowk and other areas. He also stressed on the need to focus on buildings that were not



damaged in 2015 but could be damaged in future earthquakes in order to achieve scale with retrofitting 2. Capacity building: He highlighted on the need for trainings for non-engineers, particularly for government officials and homeowners. 3. Performance criteria: Saying that there has been a lot of talks on updating these guidelines to current code, he asked if it is really what we need. He further explained that it is not always

possible to retrofit a building to current code, since homeowners have to spend a lot of money, and it can become very complicated and hard to achieve. Giving example of USA, where separate guidelines have been developed for retrofitting, he suggested that consideration should be given to come up with a criteria that would be acceptable and not necessarily in the current code, and stressed on the need to properly assess the building before developing the performance criteria. 4. Incentive to homeowners and suppliers to produce quality materials through vocational programs to achieve the material quality. 5. Technology: He said that increasing the ductility of buildings is as important as any other factors, and that splint and bandage approach increases ductility 6. Need to consider the feasibility of construction, which also includes socializing the technology 7. Financial incentives: He focused on the need for providing some means of financing to homeowners for retrofitting their homes, which could be in the form of subsidies from the government or private sector. He also said that these loans should be tied to construction quality, and that incremental retrofitting could be another option here.



Remarks from Jitendra Bothara, New Zealand

Giving a brief overview on his own experiences with retrofitting, Mr. Bothara said that his first engagement in retrofitting had been in mud building while working at NSET. He further said that there were a lot of critical voices then. Retrofitting was taken as a process rather than product then, and the by-product of that process was the mason training we see today. He stressed that the



experience had been a very useful learning, which also guided the present retrofitting practices. He particularly pointed out 3 major learnings: 1. Retrofitting is a legitimate method to reduce risk, 2. Mud mortar buildings can be easily retrofitted and 3. Even a little intervention makes a big difference in survival of buildings. He further stressed that our focus on retrofitting should be on those little interventions so that we can

take them forward in sustainable way. He also highlighted that safety is not only a technical issue, it is equally a socio-cultural and economic issue. So there is a need to integrate all these aspects in making retrofitting sustainable. He further elaborated that the current retrofitting model focusses on either meeting 100 percent standard of the code or not retrofitting at all, and that, he said, was the greatest impediment to retrofitting. Giving an example of New Zealand, he said that we can't fix everything, so there is a need to set achievable targets. Emphasizing on the concept of Incremental Retrofitting, he said that our current effort is to promote retrofitting as a product, however, it should be promoted as a process, through incremental retrofitting. He elaborated that culturally, we build houses over a period of time, and that we cannot complete a building in one go, due to various economic limitations. So he urged all to fix the most vulnerable parts first and add other components over a period of time. In retrospect, he also said that NRA could have introduced the incremental approach which could have been easily adapted by many homeowners due to its cost benefit aspects. He suggested that engineering research, specifically on vernacular building type is much needed since vernacular buildings perform very differently than modern buildings. Finally, he pointed out towards the need to fine tune research with methodology and make them easier for implementation.



Remarks from Amanda Duff, UK



Ms. Duff said that retrofitting is a fascinating topic in itself, which could be analyzed from policy, technical, economic, social and historical angles. She further said that UK has been supporting retrofitting since the 2015 earthquake, and it's interesting to see the journey since then. Finally, she stressed on the need to focus on scaling it up for wider application and how it can be applied before earthquake, through interesting tools like incremental retrofitting.

Floor discussion: Questions on FACEBOOK LIVE and ZOOM Meeting

- 1. How is NRA strategizing to minimize the effects of next mega earthquake and how differently will Nepal deal with destructive earthquakes in the future?**

From Roshan Vincent to Jhappar Singh Vishwokarma

Response: NRA has already started some initiations such as collaboration with local government. NRA is also focusing on documentation of learnings, experiences and how to transfer the learnings. It has already initiated trainings for local government, prioritizing on documenting, sharing and transferring of its learning to local government. NRA will handover important learning and experiences in making the country resilient to relevant government stakeholders. For example, local government will now play vital a role in implementation of NBC. The role of local government will be critical now, and there is a need to make some robust mechanisms in terms of technical and economic aspects as well as communication technologies. There is a need to take timely actions and work on preparedness.

- 2. Are these documents prepared based on experimental verification? Or we used only the experience based knowledge to prepare these? If these are prepared based on knowledge only, how can the designers be confident to ensure the safety level using these guidelines?**

From Sujan Tripathi to Hari Ram Parajuli



Response: The documents have been prepared using three kinds of mix methods: theoretical calculations, experimental verifications and expert opinion. Different guidelines have been set in different cases by incorporating learnings from other countries too.

3. **Are the technology recommended and used for retrofitting of non- engineered masonry buildings based on past experience/documents/manuals/guidelines or is there exact analytical calculation of capacity of existing masonry building while preparing retrofitting manual to enhance the capacity of non-engineered masonry buildings?**

From: Mahesh Raj Bhatt to Bipin Gautam

Response: It has used both experimental and analytical verifications. There are some technologies that are verified through practical methods also.

4. **We could integrate retrofitting techniques in Surakshit Awash Karyakram (Safer Housing Program) launched by Government since the last fiscal year? Surkhshit Awas Karyakram, so far, is limited in replacing thatch roofing by GI sheets, so is it possible to incorporate retrofitting there?**

From Kishore Thapa to Navaraj Pyakurel

Response: In this program, there is a need to give 5000 rupees to remove thatched roof by CGI sheets. As per the feedback from different districts and areas, there were some issues of wall, so there are on-going discussions about replacement of rafter, and jacketing of walls. So it can be considered a prototype of retrofitting. These are valid issues and we are in the process of making plans to improve this scheme in the system.

5. **Plastering of retrofitted buildings gives an illusion of new building. Can we expose all or some of the structural components so people will identify it as a retrofitted building? However, we should consider the aesthetic aspects too.**

Questions to Bipin Gautam. From Kishore Thapa

Response: Expose of retrofitting elements depends on the technology used for retrofitting. In some technologies such as strong back or splint and bandage with RCC elements, we can see the retrofitting elements in the buildings.

6. **Beneficiaries of the reconstruction are still using the old house. According to the rules, such houses must be demolished, but demolition also costs a lot of money. What kind of policy will the National Reconstruction Authority bring to strengthen and save such houses? Beneficiaries are not ready to demolish such houses in the village. Is Incremental Retrofit Useful? What is the plan of National Reconstruction Authority in this?.**

From Ram Sapkota to SushilGyewali, NRA



Response: NRA has taken certain decisions regarding financial dimensions of retrofitting since financial dimensions of retrofitting is one of reasons for low acceptance of retrofitting by the people. Keeping this into consideration, the concept of incremental retrofitting has been introduced and a grant of Rs.50000 could be used for incremental or localized retrofitting. People are given with two options: either maintain and strengthen their houses or demolish it and build new. Through this approach, NRA is trying to reduce the vulnerability of houses, and in future, there is a need to think about how to promote this technology.

7. What will be the difference between acceptable risk then? Is risk reduction only an issue of cost? Incremental things must be well defined and there is a need to identify people's acceptability.

From Ranjan Dhungel to Jitendra Bothara

Response: Acceptable risk is defined in very different ways by experts, policy makers and public. Here, we are talking about collective process and decisions coming from experts, policy makers and public. How we define risk as a collective approach is a different thing, which needs to be accepted by all and based on our culture, economy etc.





Remarks from Special Guests and Chief Guest

Remarks from Dipendranath Sharma



Thanking NRA team for such a great effort in reconstruction, Mr. Sharma said that the presentation shows that the process has developed a wealth of knowledge through creation of human capital. He provided some valuable suggestions to The Ministry of Construction and DUDBC as they will be leading the process after NRA. He said that there is a need to focus on revising the safer housing program guidelines to

include the provision of periodic maintenance and retrofitting, which will require some cost. He further opined that cost is not a problem, and presented the policy commitments and institutionalization as major issues. He also suggested that in order to ensure the sustainability and ownership of government's co-financing policy, there is a need for certain percentage of contribution from people. He also said that all the people should be covered by this program and that the government cannot leave any one behind. However, he said that incremental process could be used in terms of technical solutions to reduce the cost. He highlighted another task of taking into account the revised NBC 105. He further informed that two institutions (Urban Planning and Development Centre and National Research Centre for Building Technology) had been created 3 years back under DUDBC, with the main idea to link policy makers with professionals and academicians. He stressed on the need to activate National Research Centre for research and building capacity. He presented capacity gap as a huge issue. He further said that the first focus should be on retrofitting of public buildings to raise the faith of the people in reconstruction process. He opined that the option of choosing 3 lakh or 1 lakh was a great barrier for people to choose retrofitting. So he personally believes that more people will be willing to come forward for retrofitting if they are given only one choice of preventive retrofitting. Finally, he pointed out that it is right time that NRA transfers these knowledge to NDRRMA as well as concerned stakeholders including DUDBC, ministry of construction, and local government.



Remarks from Nawarj Pyakurel, DG, DUDBC

Mr. Pyakural said that it is right time to use NBC, and develop guidelines and documents to use NBC in various levels. He stated that one of the major questions people have is regarding the possibilities of retrofitting in mud mortar, however they have not been given complete answer to their frequently asked question. So he said that the workshop was an opportunity to give answer to the question. Saying that many buildings are still vulnerable, he focused on the need to retrofit public buildings where large number of people gather. He also stressed on the need to develop retrofitting scheme for public buildings. Giving his feedback on the three presentations, he said



that they were very specific and important, and discussed about various technical, social and economic aspects of retrofitting. He also expressed that he was happy to see norms and standards developed for retrofitting and that these norms should be approved from the government system. Lastly, he suggested that there should be some listing of retrofitting experts because it is hard to find the technical human resource when required.

Remarks Dr. Bishnu Bhandari, Executive Member, NRA



Dr. Bishnu Bhandari said that retrofitting is a composite of social, technical, environmental, social and economic process, and therefore, we need a holistic approach, without focusing on engineering aspects only. He further said that engineers have been playing an important role and they are an important component of the whole holistic process. He stressed that when we retrofit, it has to be technologically strong, culturally acceptable, economically viable and environmentally perfect.



He highlighted 5 key points as a way forward:

- Clearly articulate in the documents regarding who the users of this document are?
- Make the document very simple and locally understandable
- Clarify the huge confusion at community level regarding the difference between retrofitting and repair
- Include information on how these guidelines were developed: were there pre-tests done and who reviewed it?
- Raise awareness and interest among people, then carry trial for adaptation

Finally, he emphasized that political will and determination is equally necessary for institutionalizing retrofitting.

Remarks from Anil Pokhrel, NDRRMA



Mr. Pokhrel thanked NRA and development partners for putting the document together, while understanding the challenges and looking at the broad spectrum of possibilities in technical, social, and economic aspects. He said that the best approach is to learn from the challenges and document the challenges and learnings, so that we could take it forward together with the ministry, local government and other stakeholders. Finally, he said that NDRRMA is fortunate

to walk with NRA for 2 years to build its capacities and institutionalize its processes including retrofitting, as well as work with other partners such as DUDBC to take this forward.



Remarks from Chief Guest, Sushil Gyawali, CEO, NRA



Mr. Gyawali stated that the workshop would be an important milestone for future. He further said that the effort that NRA has made has been quite good, however it has been delayed to certain extent due to various reasons. He opined that though the number of retrofits is less, the lessons learnt are very important and would guide the future process; so retrofit can be regarded a success from that perspective.

Addressing the important concern on low numbers of retrofits, he said that the major reason behind this was lack of awareness in public and political levels. He further stated “If we go back in past, it took almost 2 and half years to come up with manuals and guidelines, so we cannot blame people that they are not convinced.” He further added, “Research on retrofit was done only after the earthquake due to which we lagged behind, and for this, the government needs to be blamed”. Thus, he emphasized on the need to come up with timely research, guidelines and manuals.

He further said that retrofitting huge number of houses requires huge investment from public, government, private sectors and also from the house owners. Since it is a huge intensity of task, we need to prepare accordingly. He also stressed on the need to replicate different retrofitting technologies. He stated that the development of guidelines, manuals and standards, videos, PSAs, poster fliers, mobile apps are important achievements.

In terms of capacity building, he said that a certain level of effort had been made, for instance 816 OJTs were conducted , 300 and 2200 engineers and masons were trained respectively, which indicates that quite a good number of human resources have been developed which needs to be



further escalated in future. He also informed that a study on urban housing retrofitting has been published, which could serve as a guide for retrofitting urban houses.

Talking about the issues and challenges, he presented the major challenges as:

- Lack of awareness
- Low level of grants and subsidies provided by government
- Lack of affordable and quality materials
- Lack of curriculum for engineers in academic courses
- Lack of clarity regarding repair, maintenance and retrofitting

Shedding light upon the benefits of retrofitting, he said that it has huge benefits, such as cost effectiveness, resilience, life safety, local adaptability and preservation of vernacular architecture.

As a way forward, he stressed on the need to increase awareness at public and political levels . He further elaborated that there is a need to come up with communications strategies and action plan for diff levels of stakeholders. He also pointed out the need for a conducive policy environment, through special social technical assistance facilities financial access program for people. He also stated that DUDBC and MoUD need to revisit national housing safety program. He suggested that comprehensive guidelines are needed for engineers, house-owners, masons and artisans alike.

He further added that different PSAs and documentaries need to be developed for wider awareness. Along with that, there is a need to document and discuss on retrofitting of Rana palaces and heritage buildings. He also suggested that huge capacity building programs should be launched for engineers, masons, bureaucrats, political representatives and other stakeholders, and that retrofitting cadres should be placed at all levels.

He advised that academic institutions should design curricula for retrofitting. He pointed out towards the need of a program for incentivizing all sectors, including construction manufacturers so that construction materials can be made available in an easy way.

Saying that reconstruction is the present and retrofitting is the future, he stressed on the need to carry open discussions with development partners about retrofitting program for a resilient technology in future. He also expressed his gratitude to World Bank for agreeing for **structural entity assessment** for health facility and school buildings, and opined that this process could also be used for wider awareness. Emphasizing on the importance of more research, he advised to establish research center in IOE, increase investment in research and strengthen research center in DUDBC under MOUD.

He stated that financial sustainability of retrofitting is very important, along with innovation of affordable technology that is viable to our country. So he said that it is duty of all to come up with innovations from financial sustainability aspects. He further added, “Incremental retrofitting could be a very good option as a process with certain level of safety.” However, he pointed out that it is



necessary to be clear on the level of safety we are talking about from our economic perspective. He also requested the team to come up with the meaning of affordable retrofitting and incremental retrofitting in our context.

Saying that, “NRA is not the future. DUDBC, MOUD and NDRMA are the future,” he requested all the concerned authorities to take the lead. He also stressed on the important role of local government urged to develop their capacity to take ownership of the process.

He further stated that multi hazard risk assessment, along with implementation of building permit system in all municipalities and RMs are very important, and said that it is the role of DUDBC and NDRMA for development of such programs. Finally, thanking all the participants, presenters, donors, organizers and supporters, he said that NRA’s support would always be there in making the whole nation resilient and hoped that it is not an end but the beginning of future.

Closing Remarks by Chairman, Shyam Kishore Singh, Project Director, CLPIU (Building)



Mr. Singh thanked all the participants, donors, participants, presenters, organizers, supporters and the entire team for their time and contribution. He said that the low level of acceptance of retrofitting needs to be increased through policy level interventions to make our community disaster resilient. He further added that retrofitting of public buildings like Singh Durbar can be a model for people to retrofit their houses, and it also shows that retrofitting is very cost-effective. He also suggested that we could replicate

retrofitting efforts from other countries like New Zealand.

He also stressed that we need to start retrofitting beyond 31 districts, and it is good to start with government buildings. He also urged that all stakeholders should sit together and plan for starting retrofitting works. He also pointed out that one consolidated document on retrofitting incorporating all guidelines would be highly beneficial. He said that norms and standards on retrofitting should be implemented soon after its approval. He also hoped for quick finalization of the document.

Finally thanking all once again, he formally announced the closure of the Workshop.



List of participants and Contributors

More than 60 people were present online, more than 40 people were present in Facebook live and 20 people were present physically, so there was a presence of more than 120 people altogether.





The following structures was made for the implementation of the workshop:

Organising Committee

- i. Chairperson: Dr. Chandra B. Shrestha, Executive Member & ICNR Convener, NRA
- ii. Member: Mr. Navaraj Pyakurel, Director General, DUDBC
- iii. Member Secretary: Mr. Shyam Kishor Singh, Project Director, CLPIU (Building)

Working Committee

- i. Coordinator: Mr. Jhapper Singh Vishokarma, DPD, CLPIU (Building)
- ii. Member: Mr. Bipin Kumar Gautam, CLPIU (Building)
- iii. Member: Deependra Nath Sharma, UNOPS
- iv. Member: Dr. Ramesh Guragain, NSET
- v. Member: Mr. Ranjan Dhungel, NSET
- vi. Member: Ms. Liva Shrestha, Build Change
- vii. Member: Ms. Pragya Pradhan, UNDP
- viii. Member: Mr. Sudin Pradhan, CRS
- ix. Member: Mr. Sushant Shrestha, UNOPS
- x. Member: Mr. Deepak Saud, HRRP