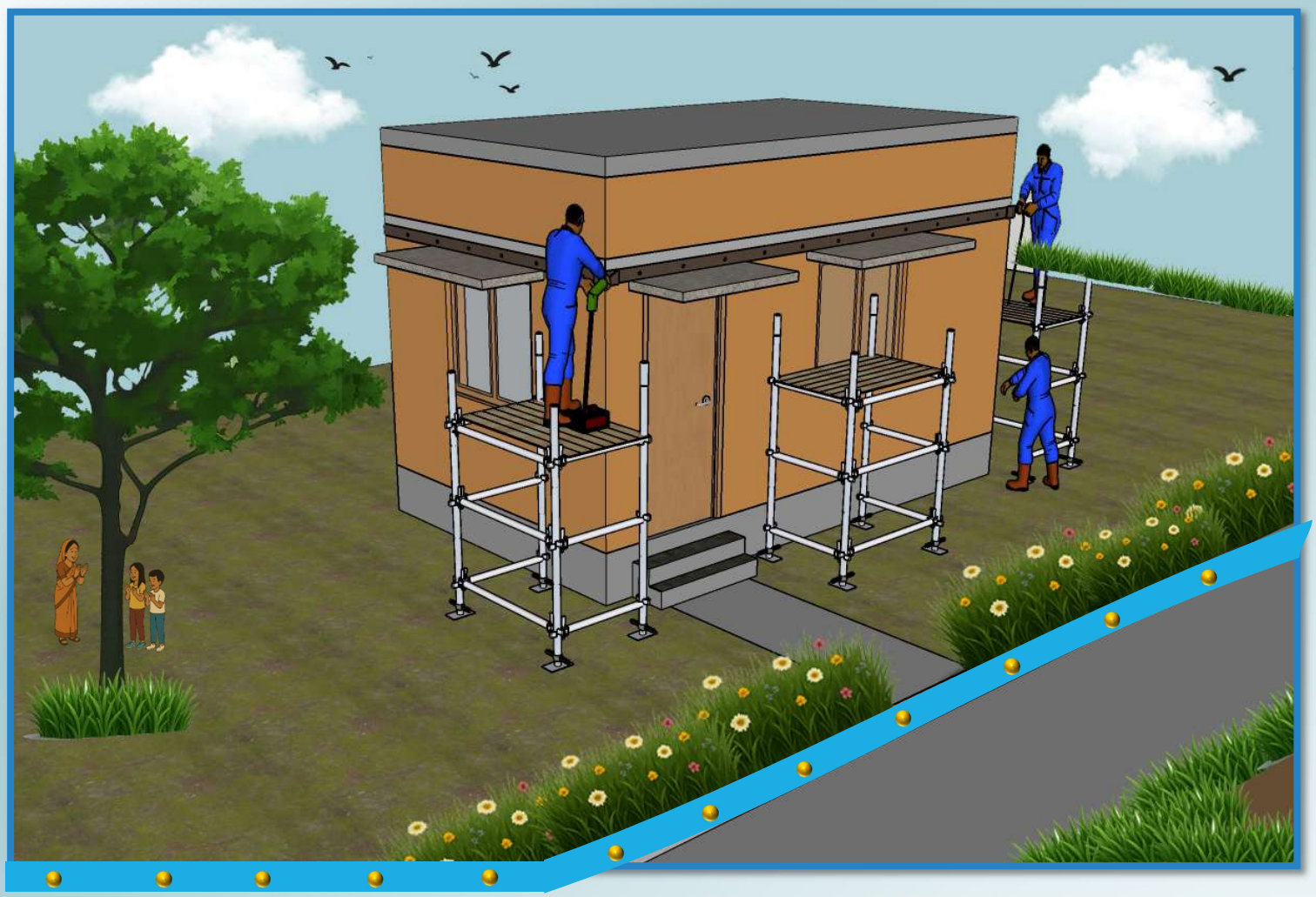
Quick, Cost-Effective & Scalable Retrofitting Technique -

STEEL TWIN LINTEL BAND: (STABLE)

for Life Enhancement of Masonry Buildings



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CSIR- Central Building Research Institute, Roorkee-247667 (India)

Foreword

The seismic vulnerability of masonry buildings remains a significant concern in India and in many earthquake-prone regions around the world. Strengthening our built environment and enhancing the safety of our communities have always been central to the mission of the CSIR-Central Building Research Institute (CBRI), Roorkee.

In this context, I am pleased to introduce **STABLE** — ***the Steel Twin Lintel Band for Advancing Building Life and Earthquake Safety*** — a quick, cost-effective, and scalable retrofitting technique designed to substantially improve the seismic performance of masonry structures. This innovative technique has been developed to address the urgent need for practical, easily adoptable solutions that can be implemented widely, even in resource-constrained and rural areas, without major disruptions or specialized equipment.

The development of STABLE is a testament to the spirit of scientific collaboration and innovation. This technique is the result of dedicated research efforts by scientists from CSIR-CBRI, Roorkee, and the Indian Institute of Technology Kanpur, by conducting full-scale tests to evaluate its performance on damaged unreinforced masonry structures. This rigorous experimental validation has ensured that the technique is not only theoretically sound but also practically effective in real-world conditions.

By enhancing the integrity of non-engineered and vulnerable masonry buildings, STABLE aims to protect lives, preserve critical infrastructure, and strengthen the resilience of our communities against future seismic events.

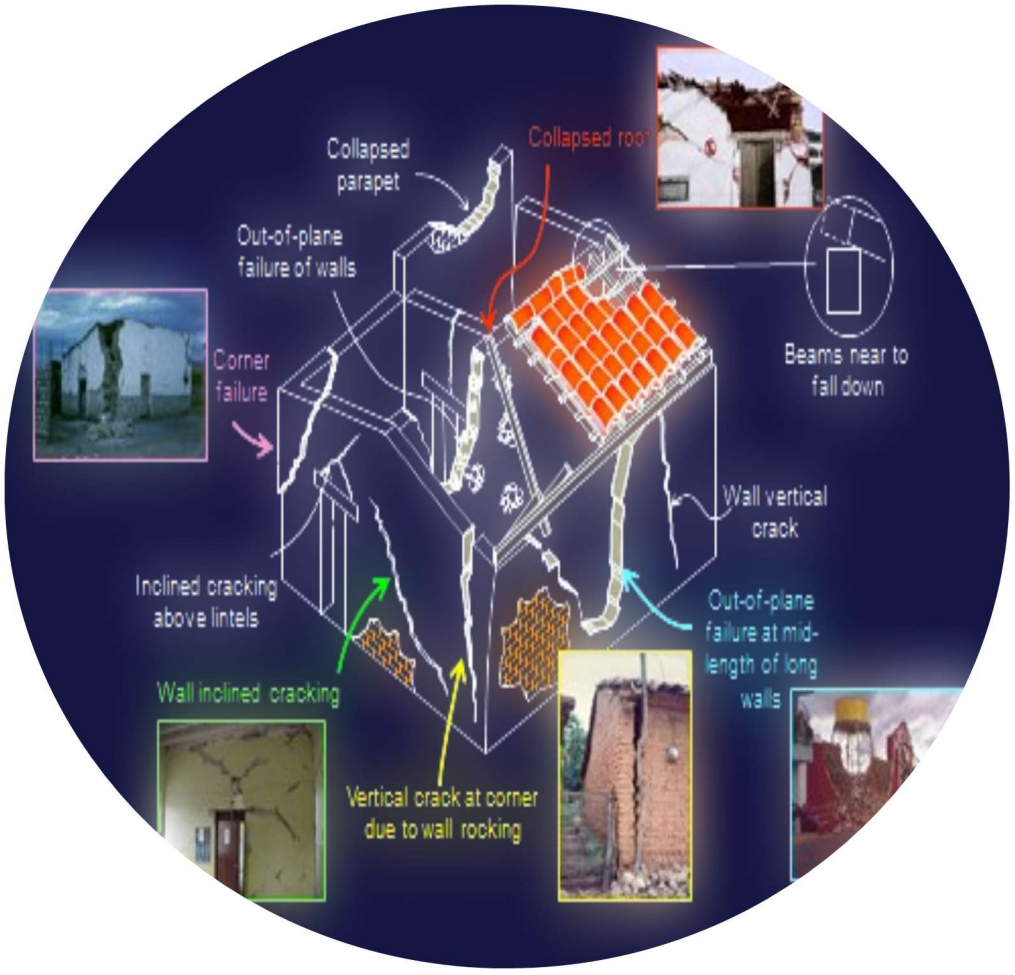
I sincerely commend the efforts of the research team for their exceptional work in developing and refining this pioneering technique. I am confident that this booklet will serve as a valuable resource for engineers, architects, builders, and policymakers, and will inspire wider adoption of retrofitting measures to build a safer and more sustainable future.

I extend my best wishes to all stakeholders engaged in implementing and promoting this important initiative. Let us work together towards realizing the vision of an earthquake-resilient India.

Prof. R. Pradeep Kumar
Director
CSIR-Central Building Research Institute, Roorkee

1. Why is this retrofitting necessary?

- 85% Buildings in India are Unreinforced Masonry
- Masonry being heterogeneous materials, its performance in past earthquakes was very poor leading to collapse of buildings
- Need of quick, cost-effective and scalable retrofitting technique, which can be executed during normal functioning


Collapsed parapet
Collapsed roof
Out-of-plane failure of walls
Corner failure
Beams near to fall down
Wall vertical crack
Inclined cracking above lintels
Out-of-plane failure at mid-length of long walls
Wall inclined cracking
Vertical crack at corner due to wall rocking

2. WHY SEISMIC BAND ?

- Connects together all walls of the building
- Attains integral box action and Provides overall stability to the Masonry structure
- Redistributing horizontal inertia forces from roof level to lower levels

Plinth Band
Sill Band
Lintel Band
Vertical Strengthening

3. What are the main Materials and Tools used in this retrofitting method?

The key materials include:

- MS flat 75X 5
- MS angle sections 35X35X3
- 10mm dia. MS Bolts 350 mm long with Double Nug & Washers
- Anti-Corrosive Coating and Paint
- Drilling Machine
- Cement Grouting Machine
- Welding Machine

❖ *Materials to be used must be of satisfactory quality as per Indian Standard*

❖ *Apply Anti-corrosive protective coatings to steel so as to prevent corrosion and ensure durability*

❖ *Proper anchorage and bonding are essential for integrating new materials with existing masonry*

Drilling Machine

MS Flat 75X5

MS Angle Sections 35X35X3

Cement Grouting Machine

10mm dia. MS Bolts 350 mm long with Double Nug & Washers

Welding Machine

Anti-Corrossive Coating & Paint

4. What steps are involved in implementing technique?

STEPS INVOLVED

- *Visual Inspection*
- *Surface Preparation*
- *Drilling*
- *Fixing MS Plate*
- *Bolting*
- *Grouting*
- *Fixing MS Plate on both wall faces*
- *Corner angle fixing & Welding*
- *Painting, Finishing*

5. How do we start retrofitting a damaged masonry wall?

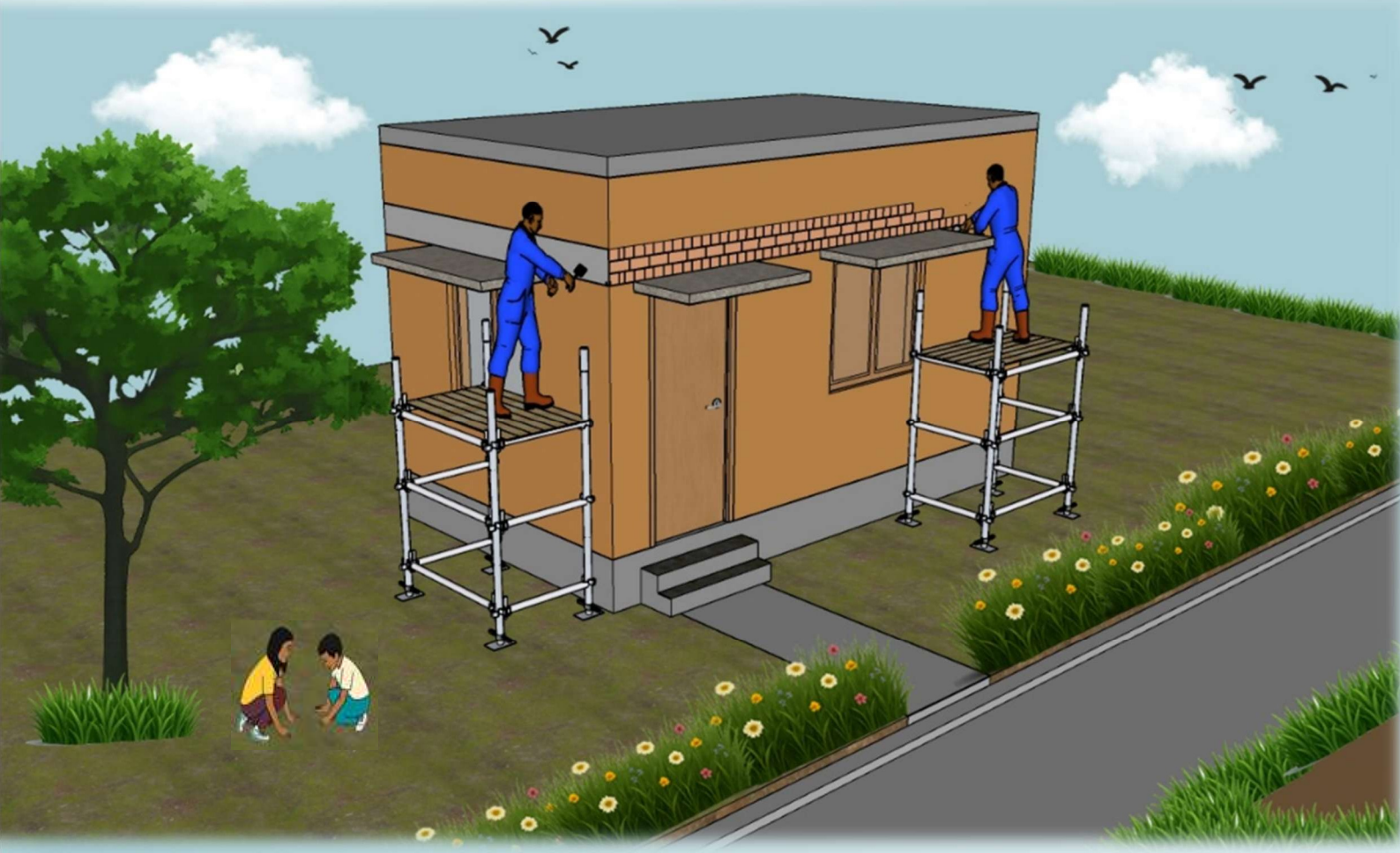
We do a **VISUAL INSPECTION…**.

- *Examine the existing masonry for visible cracks, bulging, or deterioration*
- *Record and verify the level and alignment of door and window openings*
- *Inspect the existing surface finishes to plan surface preparation accordingly*

6. What do we do before attaching anything to the wall?

SURFACE PREPARATION

- *Remove 200mm wide plaster from both wall faces along the intended levels*
- *Clean, smooth the brick wall by wire brush and apply water spray on wall surface*
- *Apply a thin cement slurry coat on prepared wall surface*



7. Now that the surface is ready, do we start attaching the retrofit material?"

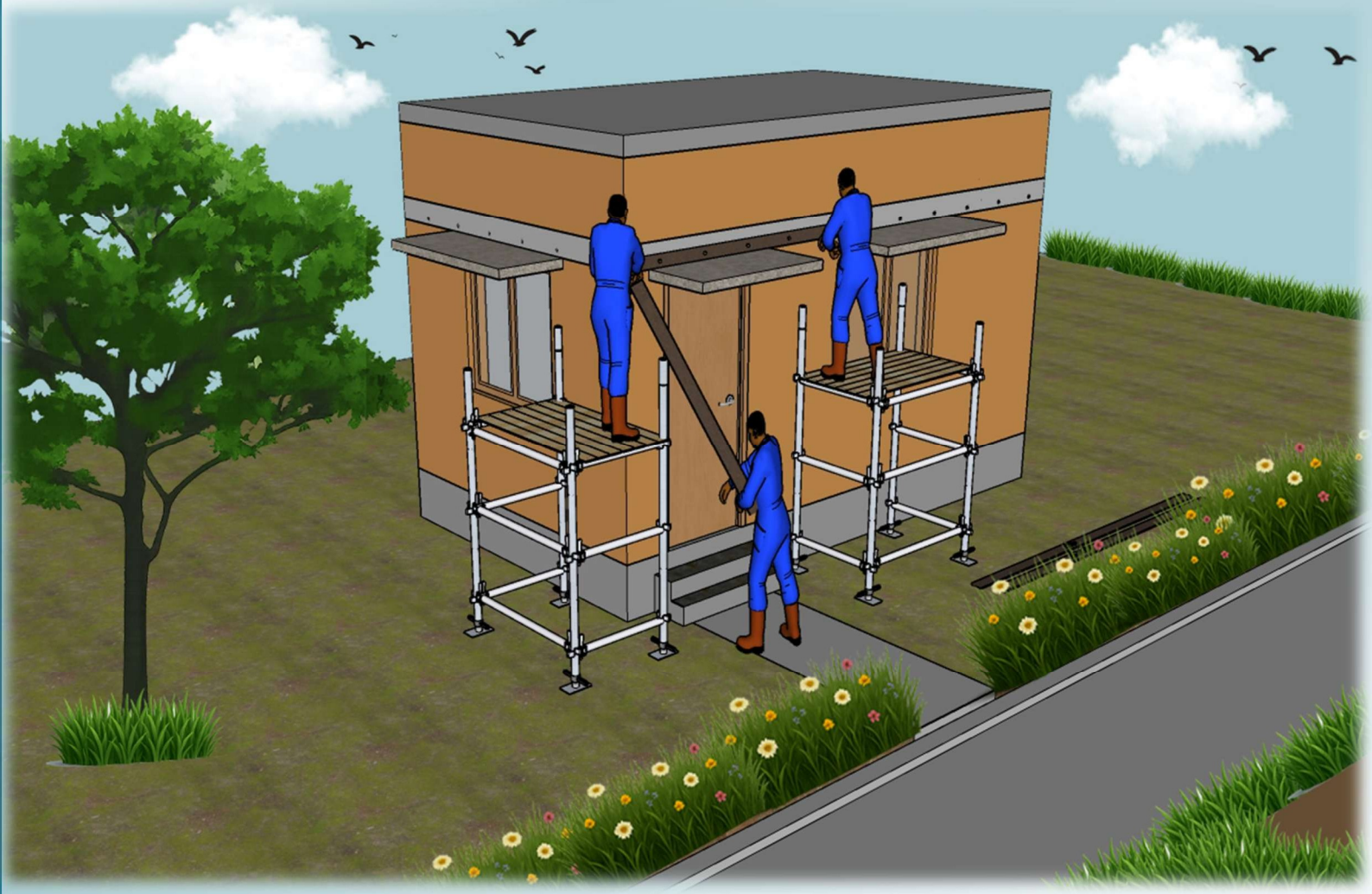
No!! before that we need to do an important process that is **DRILLING**

- *Drill 12 mm diameter holes along the band line at intervals, as per Table 1 given at the end*
- *to ensure a strong bond with the anchor system clean drilled holes using compressed air and water to remove dust and loose particles*

8. What's next after drilling?

FIXING MS FLAT

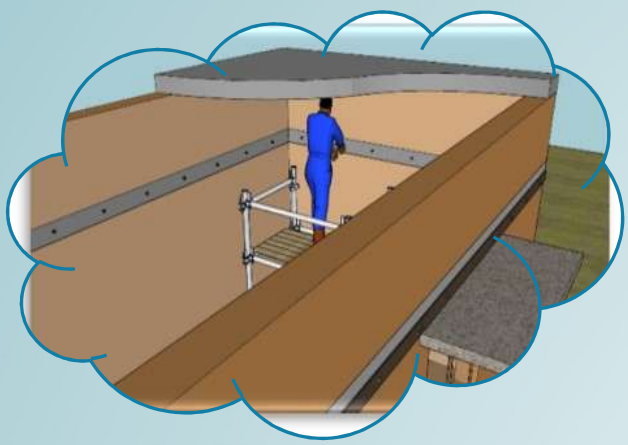
- *Position the first MS flat on outer face of the wall*
- *Temporarily fix it using bolts*
- *Insert bolts through the flat such that bolt heads remain on outer face*



9. *How do we secure MS plate firmly to the wall?*

*Through **BOLTING** we can secure the plate firmly*

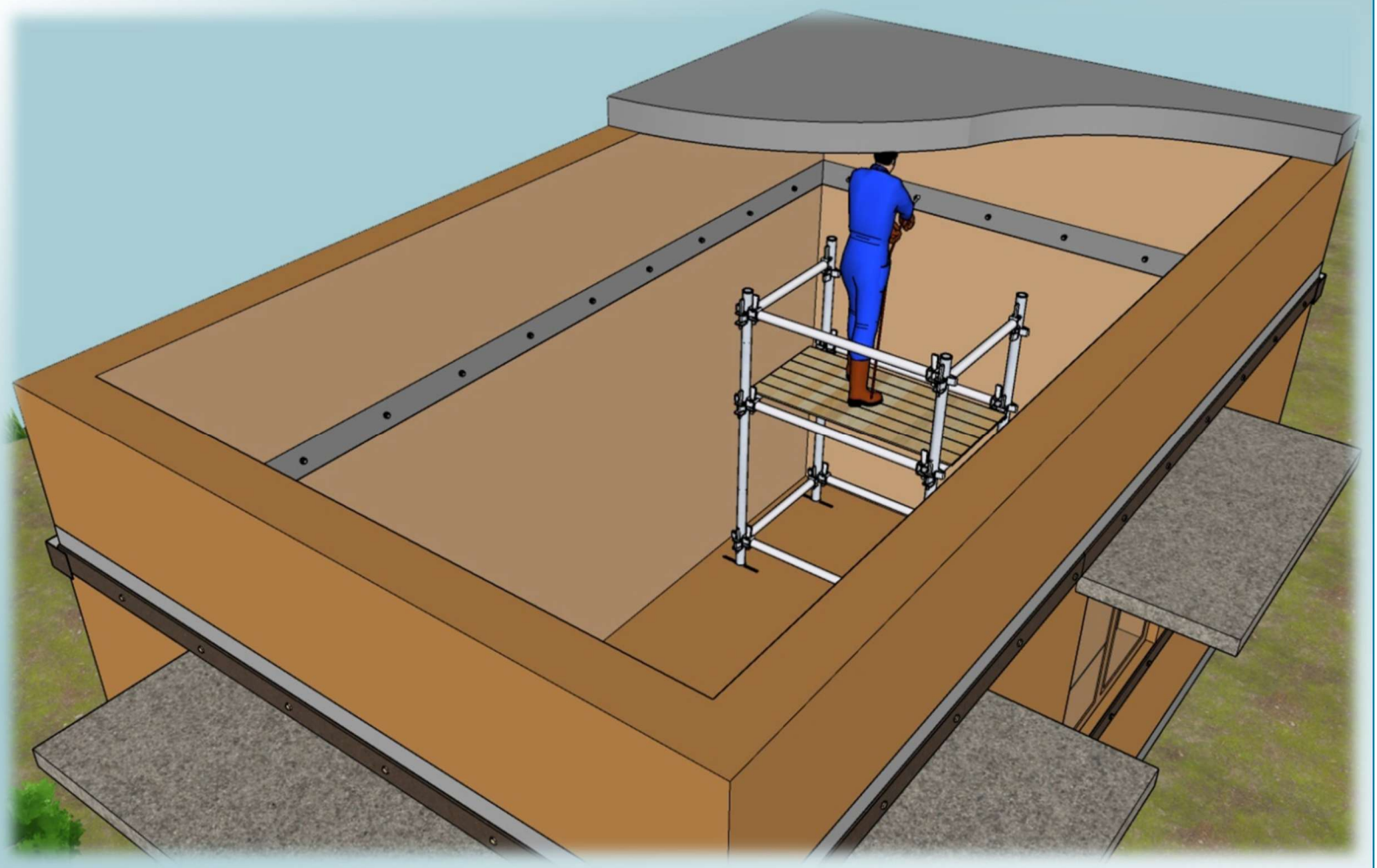
- *Insert MS bolts through the holes with head on one end, threads on the other*
- *Total length of 10mm dia MS Bolt= Head thickness+Wall thickness+50 mm (for washer+bolts); 350mm long for 230mm thick wall*
- *Apply anti-corrosive coating on all steel components prior to fixing and before painting*

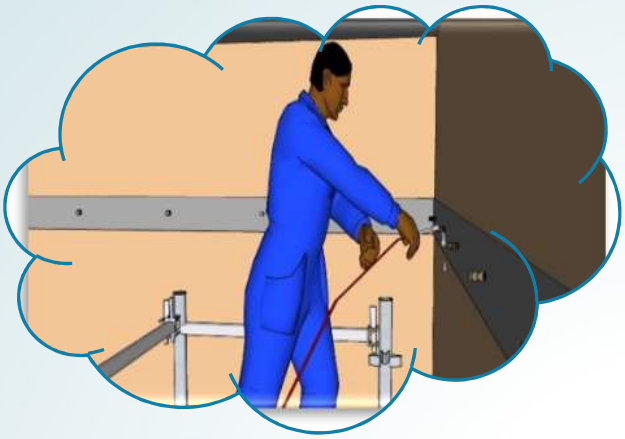


10. There's still a gap between the plate and the wall. Which is the additional procedure that is carried out for fixing MS flat even after bolting for effective anchorage?

GROUTING

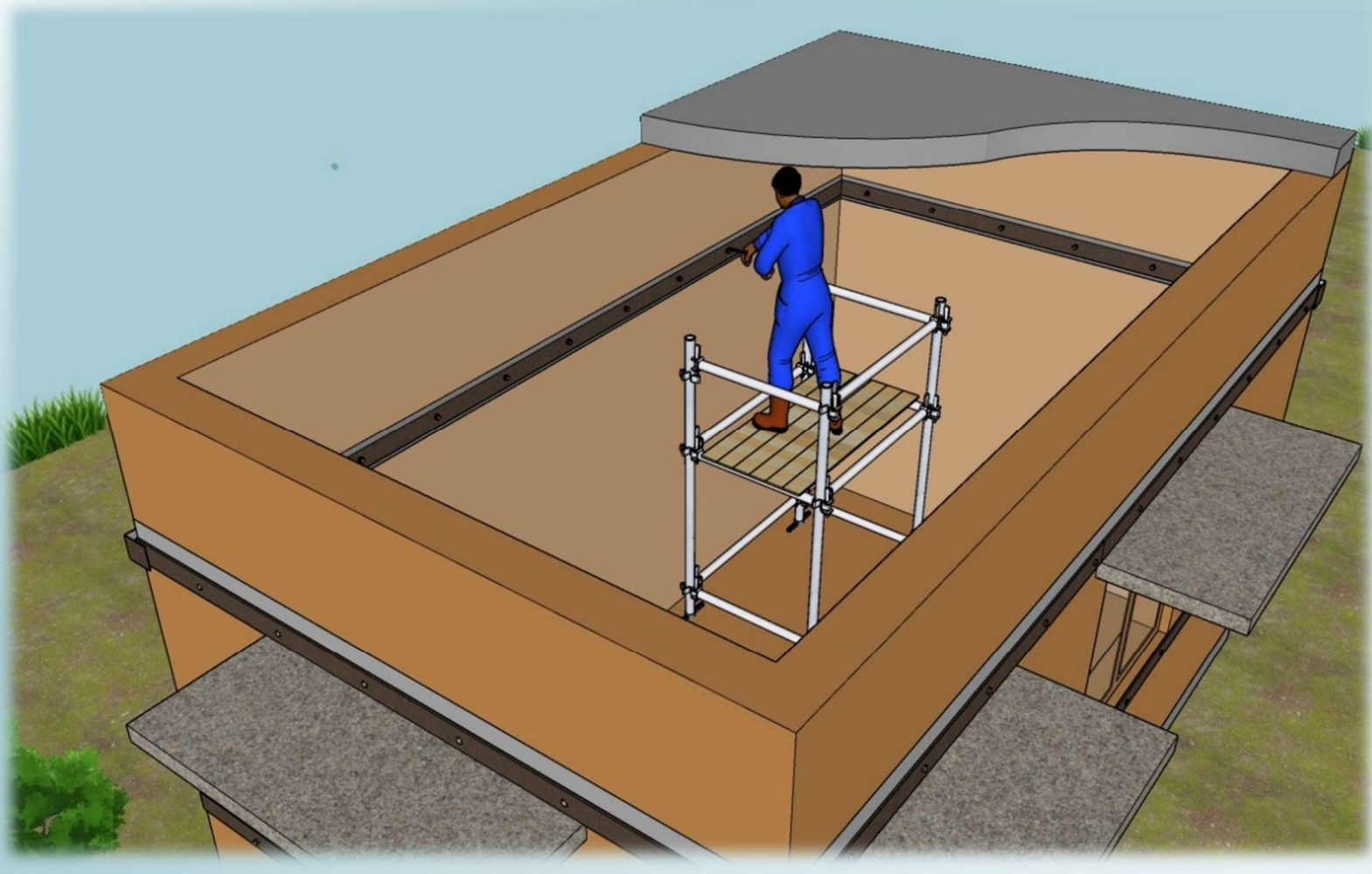
- *Inject cement grout into the drilled holes from free end of bolt (upon inserting bolts with MS Flat on one face of wall) at a pressure of 4–5 kg/cm²*
- *This improves anchorage, fills voids, and enhances bond strength*

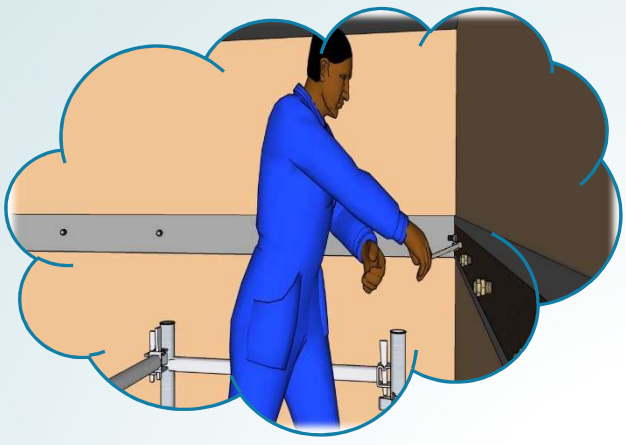




11. Will retrofitting be carried out in both interior and exterior walls of the masonry buildings?

- *Yes, it's a bilateral process where retrofitting is initiated at the exterior face of the wall at the initial stage followed by interior face of the wall- FIXING MS FLAT ON OPPOSITE FACE*
- *Position and fix the second MS flat on the opposite wall face. (parallel positioning of MS Flat inside the masonry building as like the exterior face of wall)*
- *Secure with double nuts and washers on each bolt*
- *Ensure spacing and dimensions of MS flats and bolt spacing, as per Table-1*

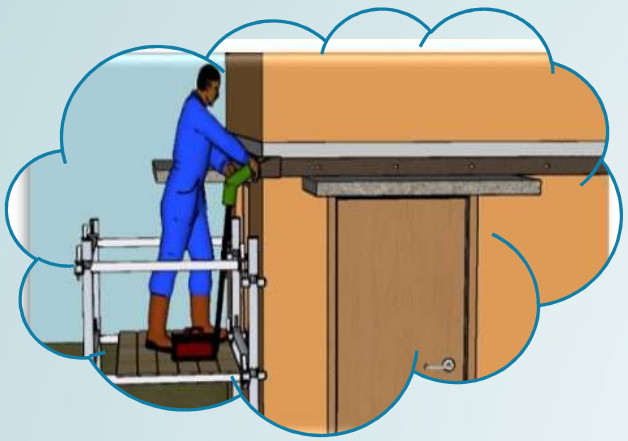


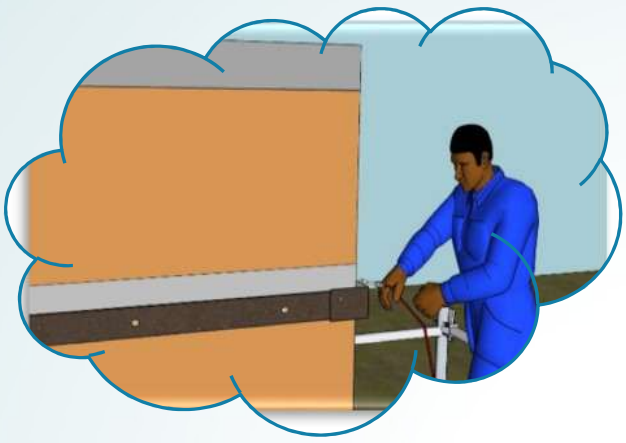


12. How to permanently fix the MS Flat at the wall junctions of a masonry building?

CORNER ANGLE FIXING AND WELDING

- *At wall junctions, fix MS corner angles to ensure lateral continuity and deformability*
- *Anchor angles to the masonry with bolts and weld to the ends of adjacent MS flats*
- *Fill any gaps between flat and wall with cementitious grout to have better contact of MS Flat with Wall*





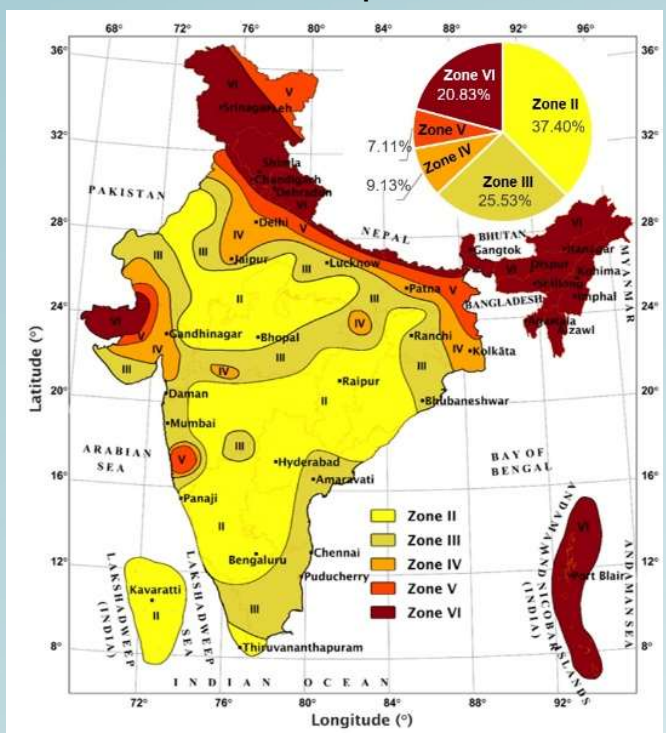
13. What is the final step involved in retrofitting of a building to gain a fully finished outlook?

- *Apply protective coatings on all steel components again*
- *Restore wall finishes using plaster and paint as per original aesthetic*
- *Reroute or accommodate electrical/plumbing services, as required*

14. How to carry out retrofitting methods for low seismic zones?

- *Zone II and III: Low seismic risk*
- *Provide lintel band as per Table-1, fixed by bolting and corner angles with welding at corners*

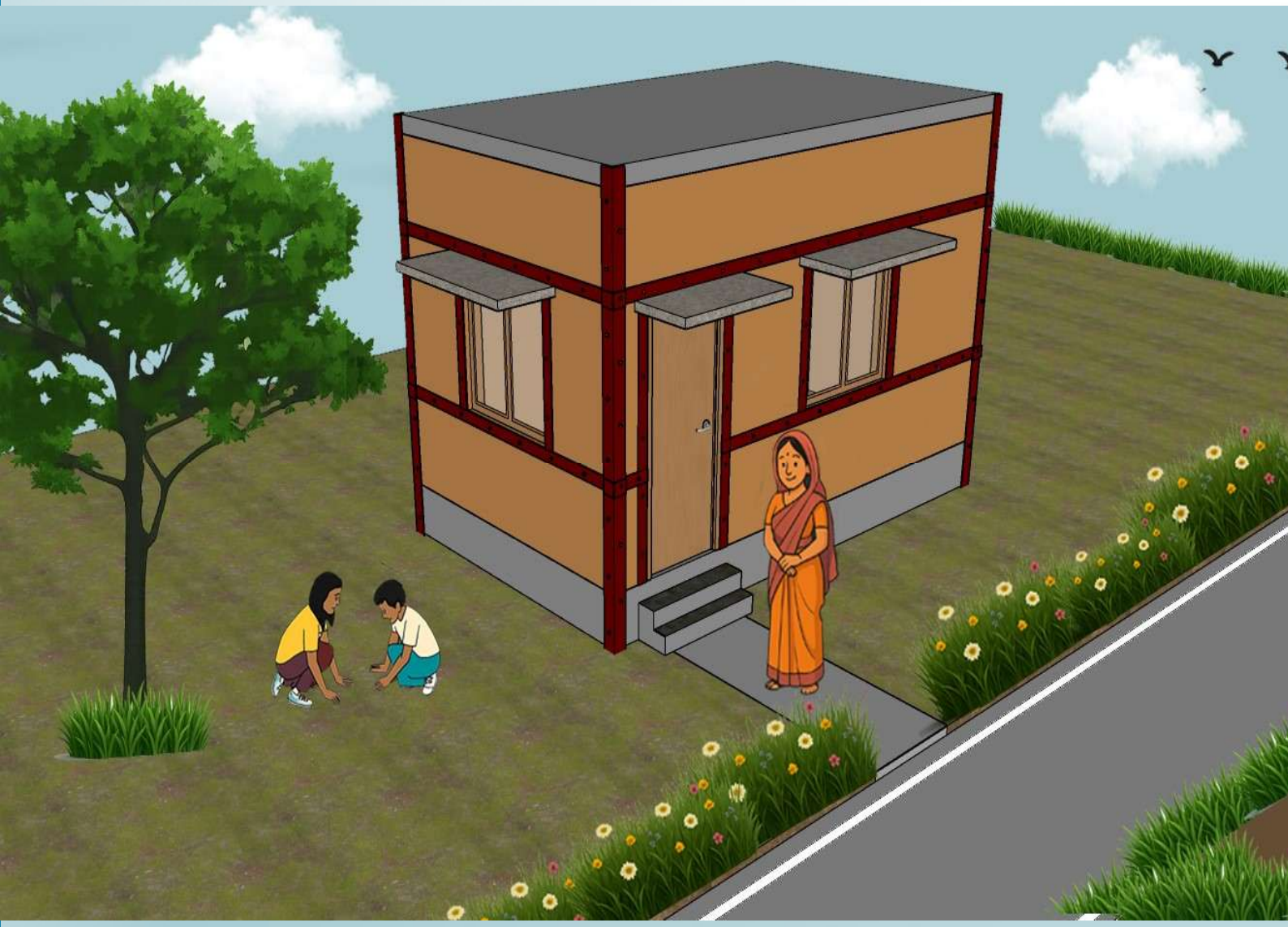
Seismic Zone Map of India

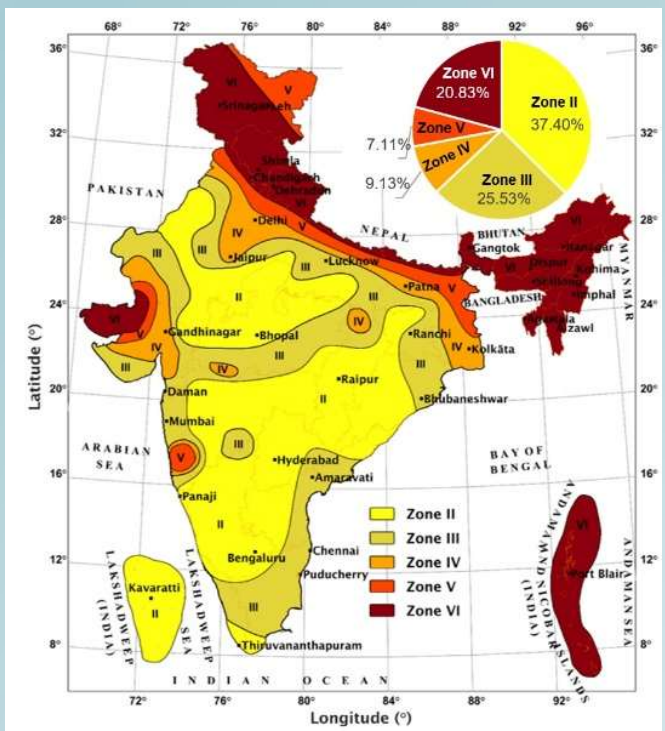


- Zone II: PGA = 0.075g
- Zone III: PGA= 0.125g
- Zone IV: PGA= 0.233g
- Zone V: PGA= 0.333g
- Zone VI: PGA= 0.500g

15. How to carry out retrofitting methods in moderate and high seismic zones?

- *Zone IV: Moderate seismic risk; Zone V: High seismic risk; Zone VI: Very high seismic risk*
- *Provide Vertical Strengthening at Corners and Intersection using Angle Section, as per Table-1, to be fixed by bolting/welding*





- **Zone II: PGA = 0.075g**
- **Zone III: PGA= 0.125g**
- **Zone IV: PGA= 0.233g**
- **Zone V: PGA= 0.333g**
- **Zone VI: PGA= 0.500g**

16. How to provide seismic strengthening methods for Masonry buildings?

- *Provide MS Flat, Bolt Spacing and Corner Vertical Strengthening Angle based on different parameters such as Seismic Zone and number of storey in building to be retrofitted.*

Table-1: Seismic Zonewise MS Flat Sections, Bolt Spacing and Corner Vertical Strengthening

Table-1: Seismic Zone-wise MS Flat Sections, Bolt Spacing and Corner Vertical Strengthening

Zone / Storey	Parameters	Zone II	Zone III	Zone IV	Zone V	Zone VI
1st Storey	MS Flat Section Size	ISF 65x3	ISF 65x3	ISF 65x5	ISF 75x5	ISF 75x5
	Bolt Diameter (mm)	10ϕ	10ϕ	10ϕ	10ϕ	10ϕ
	Bolt Spacing (mm)	@ 500 C/C	@ 500 C/C	@ 500 C/C	@ 500 C/C	@ 400 C/C
	Corner Vertical Angle(mm)	-		ISA 35x35x3	ISA 50x50x3	ISA 65x65x4
2nd Storey	MS Flat Section Size	ISF 65x3	ISF 65x3	ISF 75x5	ISF 75x5	ISF 90x5
	Bolt Diameter (mm)	10ϕ	10ϕ	10ϕ	10ϕ	10ϕ
	Bolt Spacing (mm)	@ 500 C/C	@ 500 C/C	@ 400 C/C	@ 400 C/C	@ 400 C/C
	Corner Vertical Angle(mm)	-		ISA 35x35x3	ISA 50x50x3	ISA 65x65x4
3rd Storey	MS Flat Section Size	ISF 65x3	ISF 75x3	ISF 75x6	ISF 90x5	ISF 100x5
	Bolt Diameter (mm)	10ϕ	10ϕ	10ϕ	10ϕ	10ϕ
	Bolt Spacing (mm)	@ 500 C/C	@ 500 C/C	@ 350 C/C	@ 300 C/C	@ 300 C/C
	Corner Vertical Angle(mm)	-	ISA 25x25x3	ISA 35x35x3	ISA 50x50x3	ISA 65x65x4
4th Storey	MS Flat Section Size	ISF 65x3	ISF 75x3	ISF 75x6	ISF 90x5	ISF 125x5
	Bolt Diameter (mm)	10ϕ	10ϕ	10ϕ	10ϕ	10ϕ
	Bolt Spacing (mm)	@ 500 C/C	@ 500 C/C	@ 350 C/C	@ 250 C/C	@ 300 C/C
	Corner Vertical Angle (mm)	-	ISA 25x25x3	ISA 35x35x3	ISA 50x50x3	ISA 65x65x4

17. What is the cost of Retrofitting of buildings in different seismic zones?

- *Cost of retrofitting of buildings differ depending on the number of stories with respect to their Seismic zones.*

RETROFIT COST (Rupees/ Sq. Ft.)

RETROFIT COST (Rupees/ Sq. Ft.)

Zone/ Floor	Zone II	Zone III	Zone IV	Zone V	Zone VI
1st Storey	150	200	250	300	400
2nd Storey	150	260	315	350	500
3rd Storey	200	275	345	475	550
4th Storey	200	300	450	525	575

About the Innovators:

Prof. C.V.R. Murty

A renowned earthquake engineering expert, Prof. Murty presently Professor at IIT Madaras (formerly at IIT Kanpur and Jodhpur) has made pioneering contributions to seismic design and safety of structures in India. He has been instrumental in advancing earthquake-resistant construction and capacity building nationwide.

Dr. Ajay Chourasia

A leading scientist at CSIR-CBRI, Dr. Chourasia specializes in seismic risk assessment and retrofitting of masonry and RC structures. His work focuses on developing practical, scalable solutions to improve structural resilience.

Dr. Shailesh Agrawal

An eminent researcher and Executive Director of BMTPC, Dr. Agrawal has championed the promotion of innovative, cost-effective construction technologies and disaster-resistant

Innovators:

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Dr. Shailesh K Agrawal
Prof. C V R Murty

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