उत्तराखंड, त्रिपुरा और महाराष्ट्र राज्य में प्रशिक्षण और प्रदर्शन
Training & Demonstration in the state of Uttarakhand, Tripura and Maharashtra



तेज़, किफायती और स्केलेबल रिट्रोफिटिंग तकनीक
Quick, Cost-Effective & Scalable Retrofitting Technique -

स्टील ट्विन लिंटल बैंड: (स्थिर)
STEEL TWIN LINTEL BAND: (STABLE)

ईंट-पत्थर की इमारतों के जीवन को बढ़ाने के लिए
for Life Enhancement of Masonry Buildings

सी. एस. आई. आर. - केंद्रीय भवन अनुसंधान संस्थान, रुड़की-247667 (भारत)
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.

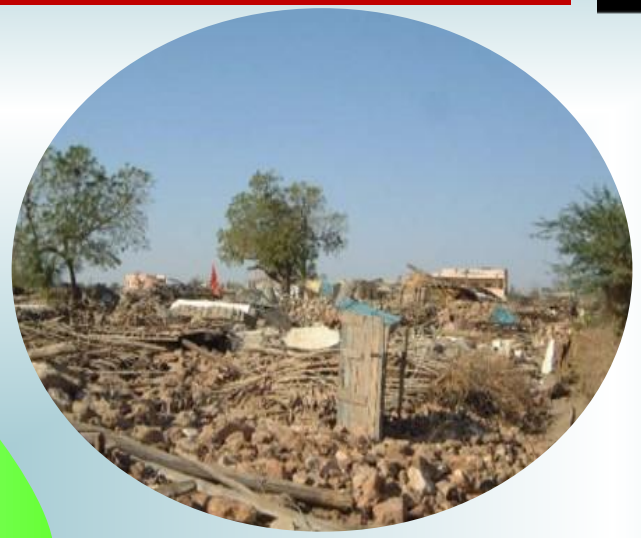
I sincerely commend the efforts of the research team for their exceptional work in developing and refining this pioneering technique. I am confident that this booklet will serve as a valuable resource for engineers, architects, builders, and policymakers, and will inspire wider adoption of retrofitting 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. By now, the technology demonstration has been done in the states of – Uttarakhand, Tripura and Maharashtra. This activity was clubbed with a course on Retrofitting of Buildings, and it is expected that engineers will take this forward to retrofit the towns. Let us work together towards realizing the vision of an earthquake-resilient India.

Prof. R. Pradeep Kumar
Director

MOTIVATION







- *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*

WHY SEISMIC BAND ?



- *Plinth Band*
- *Sill Band*
- *Lintel Band*
- Vertical Strengthening

- *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*

RETROFIT TOOLS AND MATERIALS

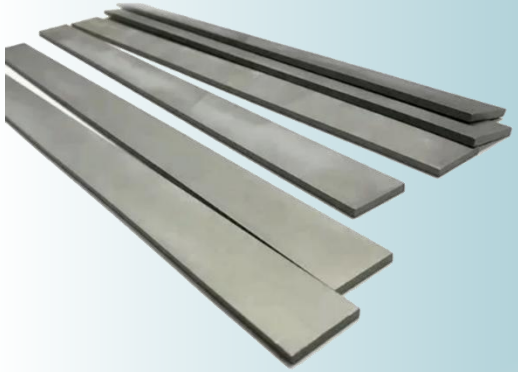


Drilling Machine



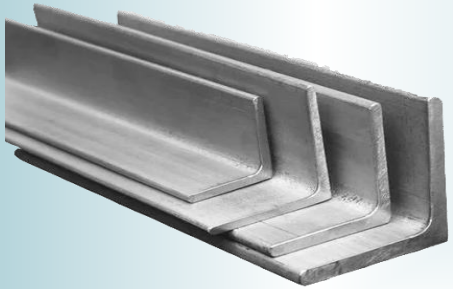
10mm dia. MS Bolts 350 mm long with Double Nug & Washers

MS Flat 75X5



Cement Grouting Machine





MS Angle Sections 35X35X3



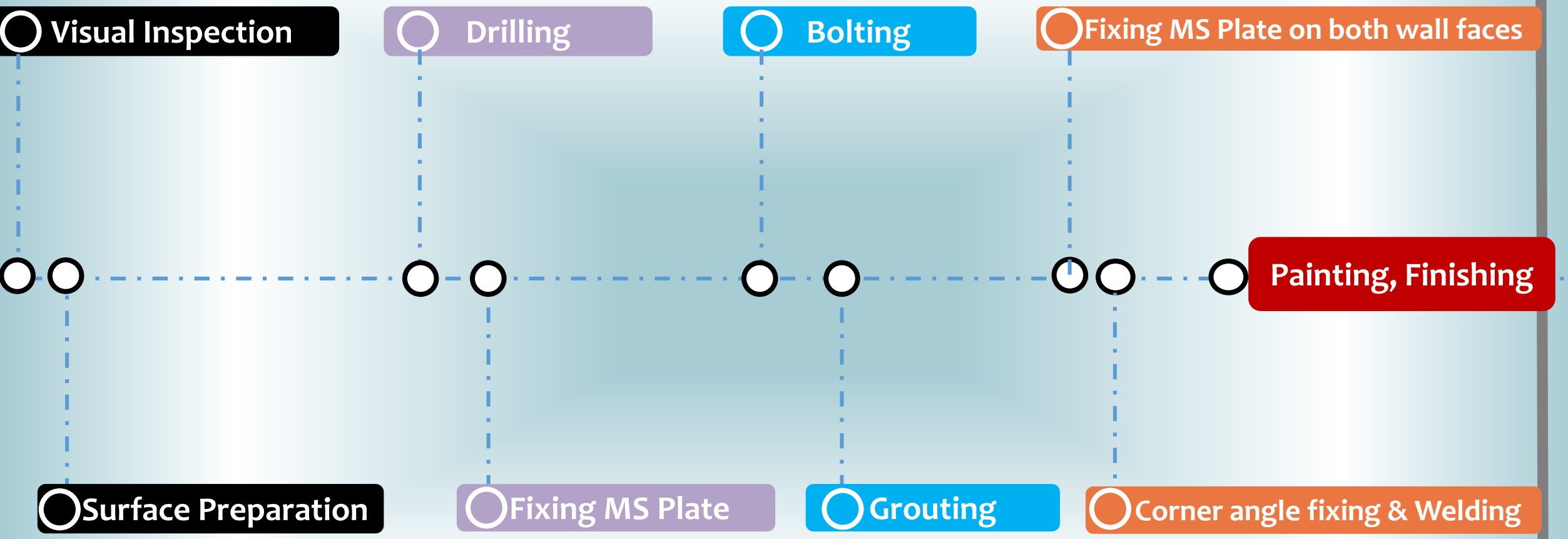
Welding Machine



Anti-Corrossive Coating & Paint

- 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

STEPS INVOLVED



VISUAL INSPECTION

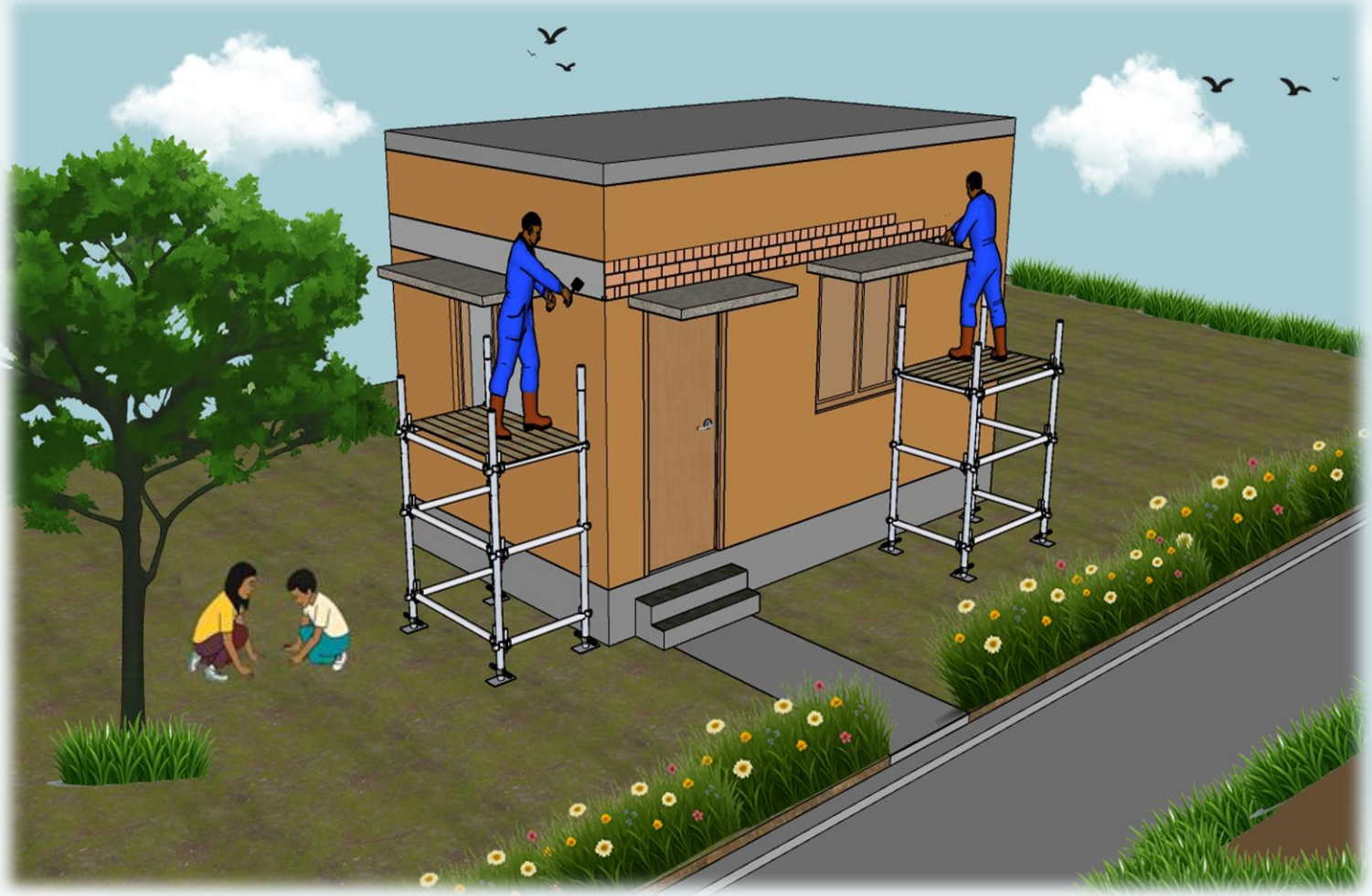
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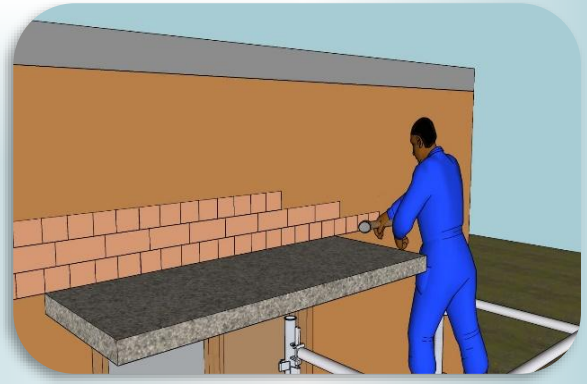


- *Examine the existing masonry for visible cracks, bulging, or deterioration*
- *Record and verify the level and alignment of door and window openings*
- *Inspect the existing surface finishes to plan surface preparation accordingly*

SURFACE PREPARATION

2







- *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*

DRILLING

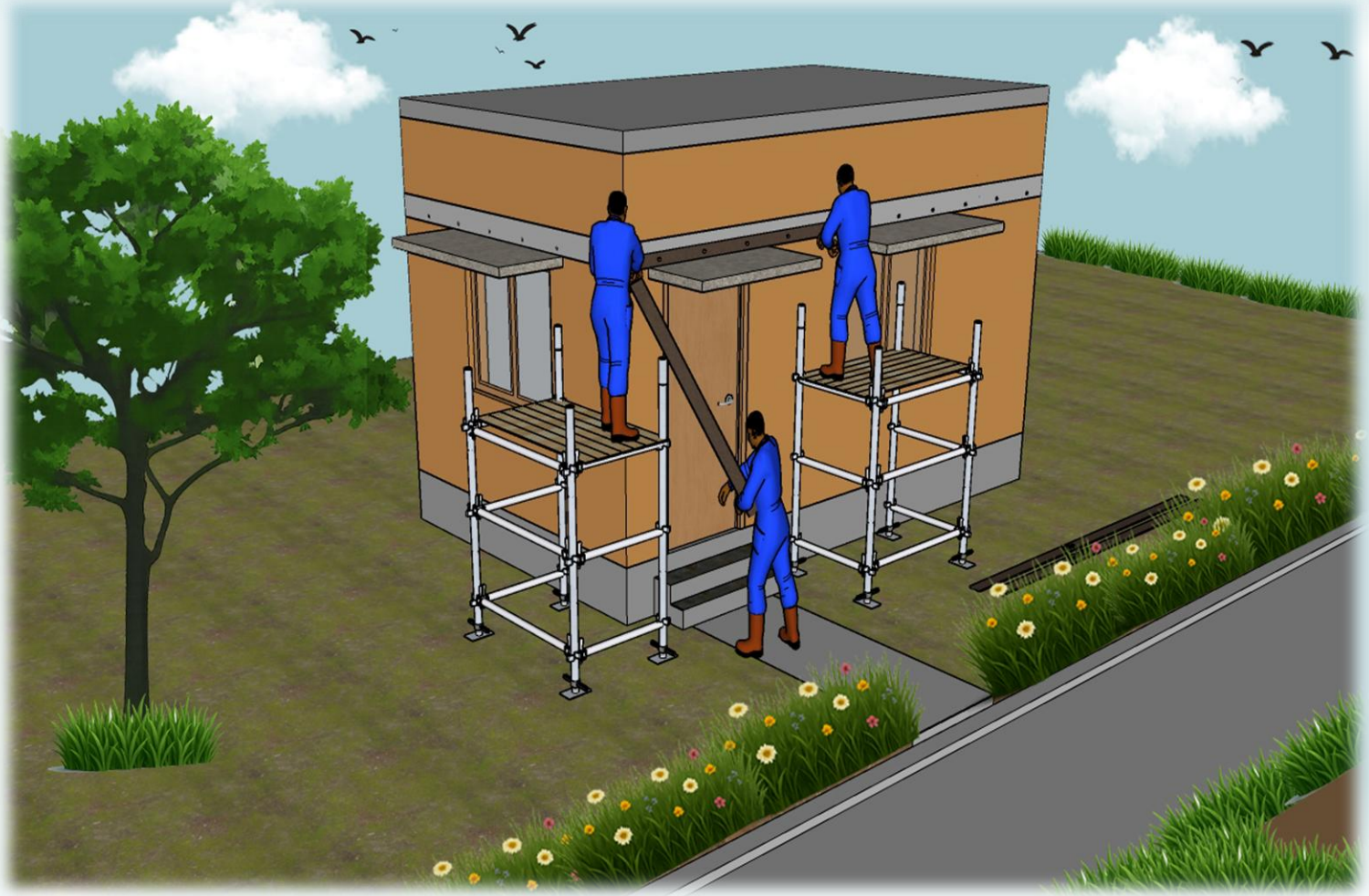
3



- *Drill 12 mm diameter holes along the band line at intervals, as per Table 1 given at the end*
- *Clean drilled holes using compressed air and water to remove dust and loose particles*

FIXING MS FLAT

4

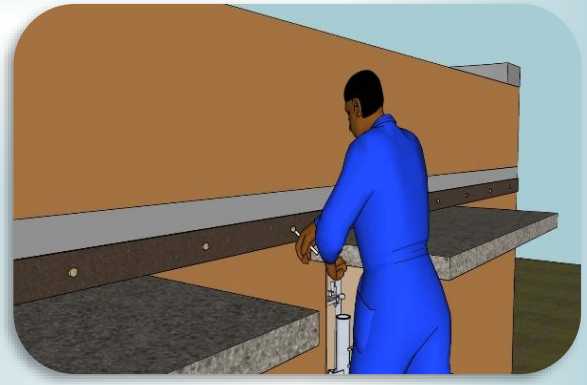


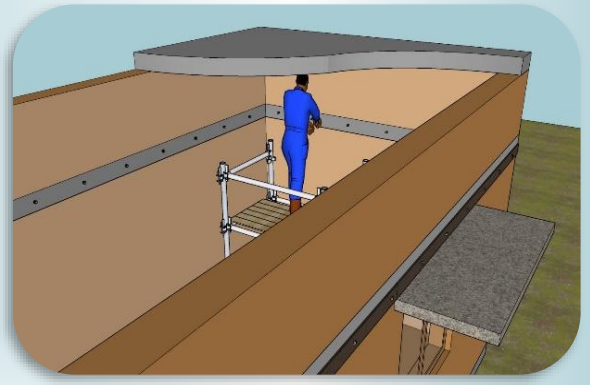
- *Position the first MS flat on outer face of the wall*
- *Temporarily fix it using bolts*
- *Insert bolts through the flat such that bolt heads remain on outer face*

BOLTING

5



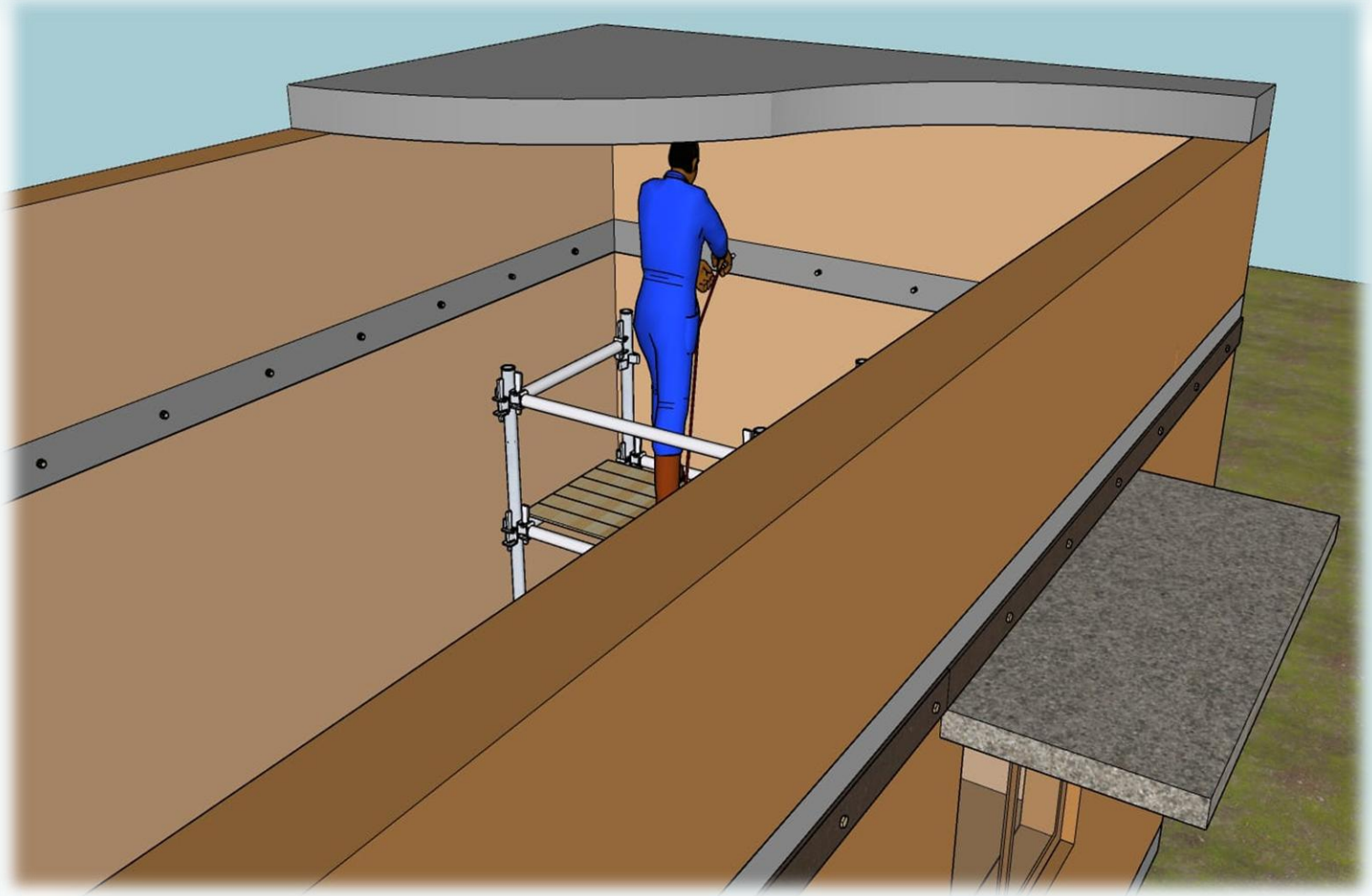


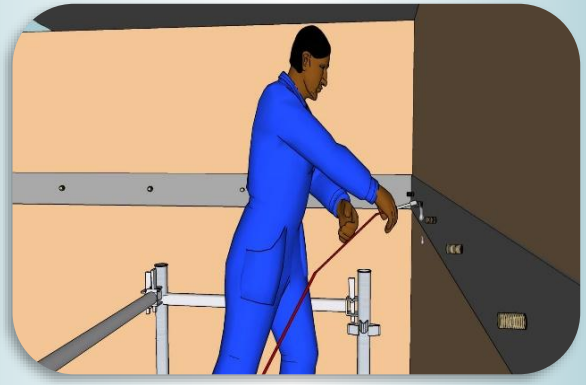


- *Insert MS bolts through the holes with head on one end, threads on the other*
- *Total length of 10mm dia MS Bolt= Head thickness+Wall thickness+50 mm (for washer+bolts); 350mm long for 230mm thick wall*
- *Apply anti-corrosive coating on all steel components prior to fixing and before painting*

GROUTING

6

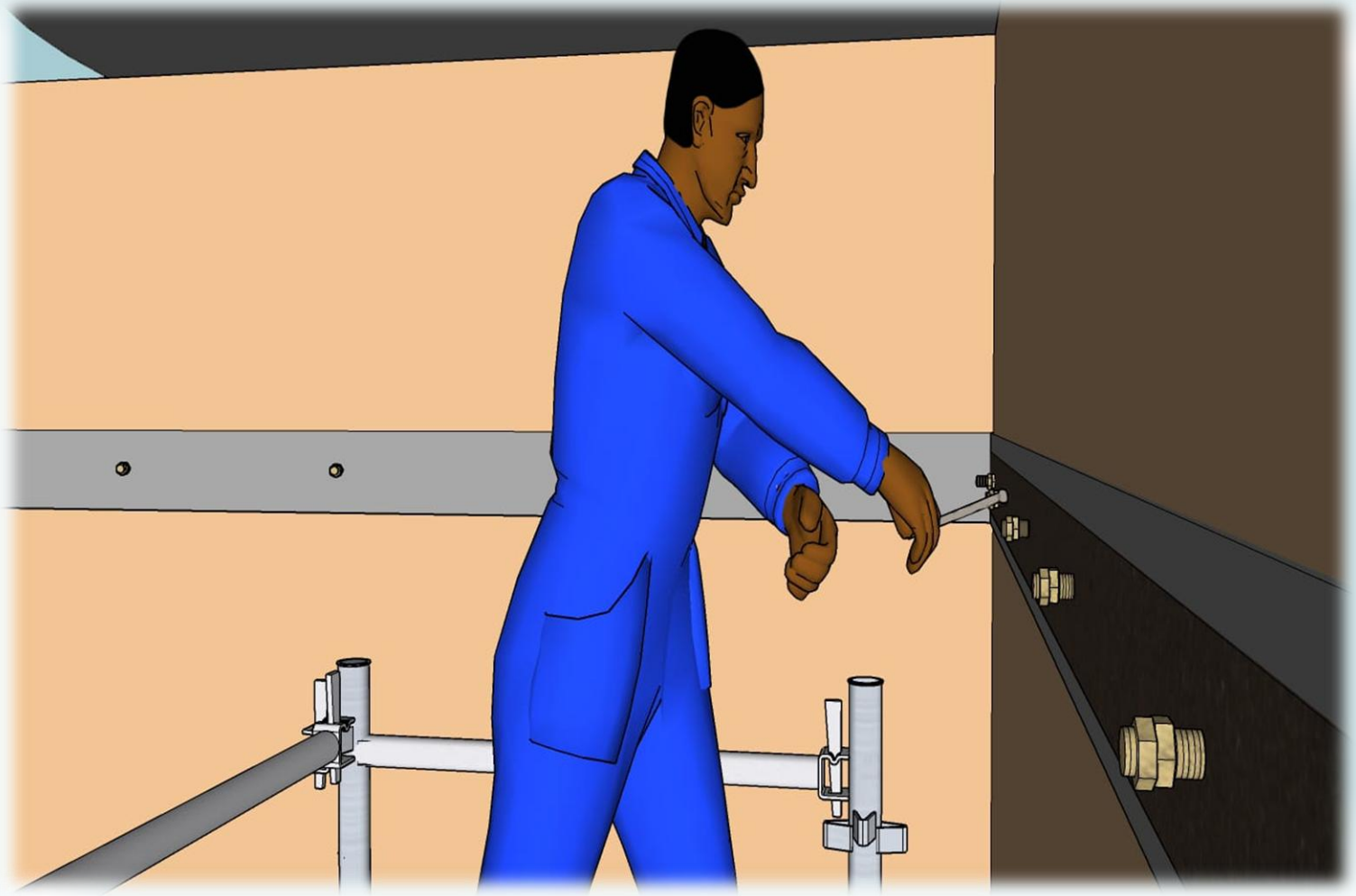




- *Inject cement grout into the drilled holes from free end of bolt (upon inserting bolts with MS Flat on one face of wall) at a pressure of 4–5 kg/cm²*
- *This improves anchorage, fills voids, and enhances bond strength*

FIXING MS FLAT ON OPPOSITE FACE

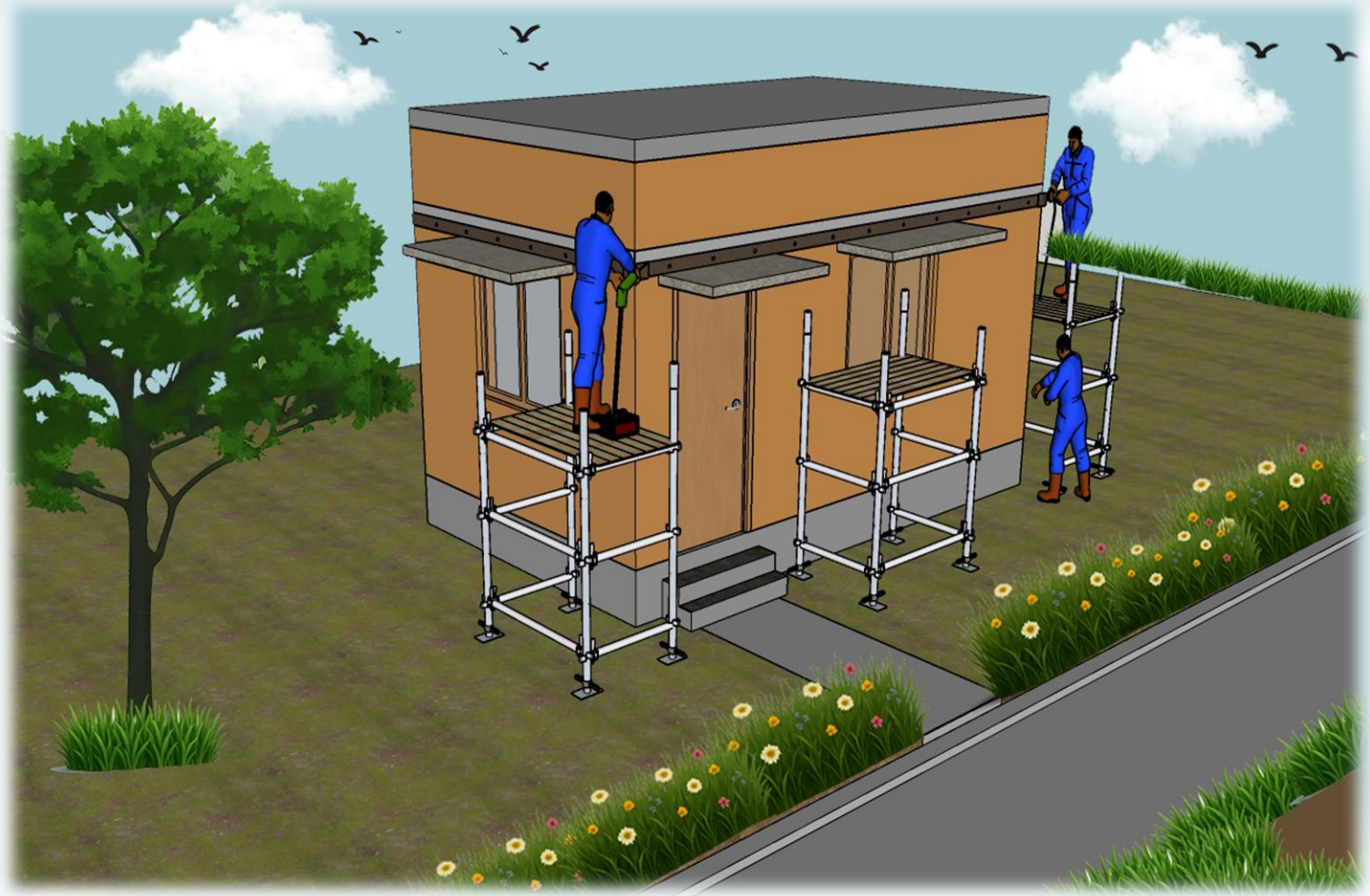
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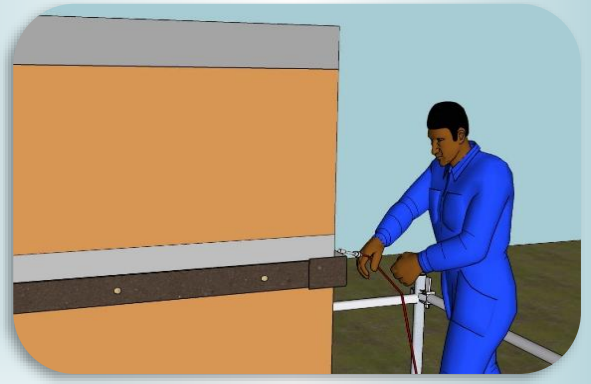
- *Position and fix the second MS flat on the opposite wall face*
- *Secure with double nuts and washers on each bolt*
- *Ensure spacing and dimensions of MS flats and bolt spacing, as per Table-1*

CORNER ANGLE FIXING AND WELDING

8







- *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*

PAINTING & FINISHING

9



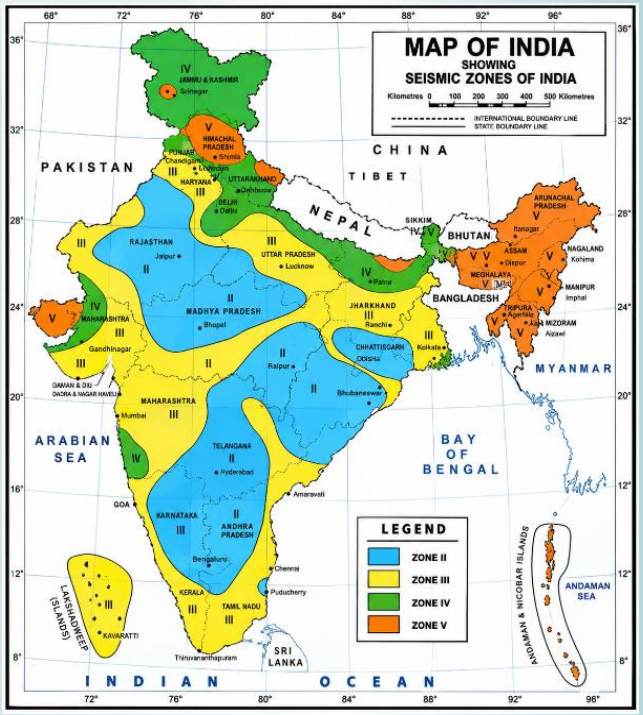
- *Apply protective coatings on all steel components again*
- *Restore wall finishes using plaster and paint as per original aesthetic*
- *Reroute or accommodate electrical/plumbing services, as required*

FOR LOW SEISMIC ZONES

10



Seismic Zone Map of India



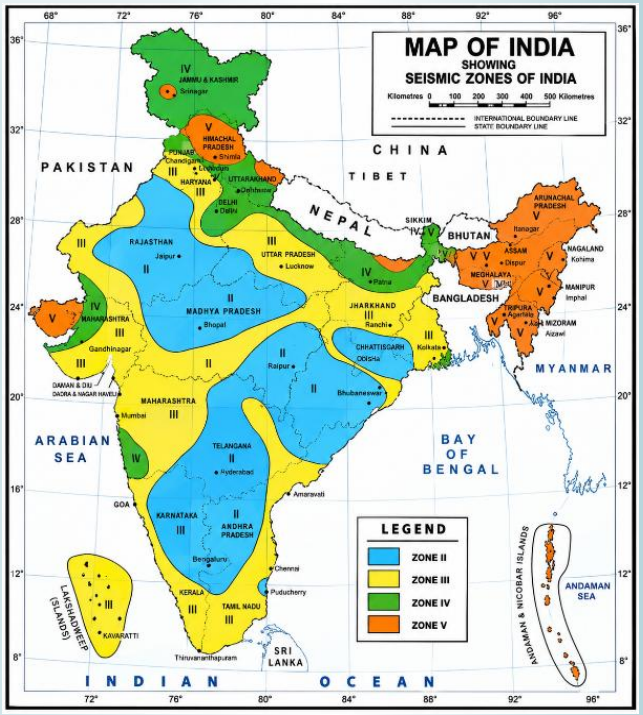
- *Zone A/B: Low seismic risk*
- *Provide lintel band as per Table-1, fixed by bolting and corner angles with welding at corners*

FOR MODERATE & HIGH SEISMIC ZONES

11



Seismic Zone Map of India



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

SEISMIC STRENGTHENING FOR MASONRY BUILDINGS

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
1st Storey	MS Flat Section Size	ISF 65x3	ISF 65x5	ISF 65x5	ISF 75x5
	Bolt Diameter (mm)	10ϕ	10ϕ	10ϕ	10ϕ
	Bolt Spacing (mm)	@ 500 C/C	@ 500 C/C	@ 500 C/C	@ 500 C/C
	Corner Vertical Angle(mm)	-	ISA 25x25x3	ISA 35x35x3	ISA 50x50x3
2nd Storey	MS Flat Section Size	ISF 65x3	ISF 65x5	ISF 90x5	ISF 90x5
	Bolt Diameter (mm)	10ϕ	10ϕ	10ϕ	10ϕ
	Bolt Spacing (mm)	@ 500 C/C	@ 500 C/C	@ 400 C/C	@ 400 C/C
	Corner Vertical Angle(mm)	-	ISA 25x25x3	ISA 35x35x3	ISA 50x50x3
3rd Storey	MS Flat Section Size	ISF 75x3	ISF 75x5	ISF 100x5	ISF 125x5
	Bolt Diameter (mm)	10ϕ	10ϕ	10ϕ	10ϕ
	Bolt Spacing (mm)	@ 500 C/C	@ 500 C/C	@ 350 C/C	@ 300 C/C
	Corner Vertical Angle(mm)	-	ISA 25x25x3	ISA 35x35x3	ISA 50x50x3
4th Storey	MS Flat Section Size	ISF 75x3	ISF 75x5	ISF 120x5	ISF 125x8
	Bolt Diameter (mm)	10ϕ	10ϕ	10ϕ	10ϕ
	Bolt Spacing (mm)	@ 500 C/C	@ 500 C/C	@ 350 C/C	@ 250 C/C
	Corner Vertical Angle (mm)	-	ISA 25x25x3	ISA 35x35x3	ISA 50x50x3

❖ *Provide MS Flat, Bolt Spacing and Corner Vertical Strengthening Angle as per above, based on seismic zone and number of story in building to be retrofitted*

INDICATIVE RETROFIT COST (Rupees/Sq. Ft.)

Zone/ Floor	Zone II	Zone III	Zone IV	Zone V
1st Storey	150	200	275	315
2nd Storey	150	260	315	380
3rd Storey	200	300	425	510
4th Storey	200	300	475	560

Indicative costs vary with building condition and detailing. Reported execution costs: Roorkee ₹250 per sq ft, Agartala ₹300 per sq ft and Hingoli ₹175 per sq ft.

TRAINING AND LIVE DEMONSTRATION



Roorkee



Agartala



Hingoli

Uttarakhand, Tripura and Maharashtra

Courses on Retrofitting of Buildings combined classroom instruction with live field implementation.

TRAINING AND LIVE RETROFIT AT ROORKEE





Training and Capacity Building Programme

Residential Building C-27, CSIR-CBRI, Roorkee, Uttarakhand

23–27 March 2026

Classroom sessions were followed by a live demonstration on an existing residential masonry building.

ROORKEE: COMPLETED RETROFIT AND COST





Approximate executed retrofit cost

₹250 per sq ft

Reported for the Roorkee demonstration. Actual cost will vary with building condition, detailing, access, local labour and finishing requirements.

The demonstration completed a continuous steel twin lintel band on the internal and external wall faces of the residential building.

TRAINING AND LIVE RETROFIT AT AGARTALA





Training and Capacity Building Programme
Building of Medical College Sub-Division No. I
Kunjaban, Agartala, West Tripura
28–30 September 2026

Technical sessions were supported by hands-on installation of the steel twin lintel band at the selected building.

AGARTALA: COMPLETED RETROFIT AND COST





Approximate executed retrofit cost

₹300 per sq ft

Reported for the Agartala demonstration. Actual cost will vary with building condition, detailing, access, local labour and finishing requirements.

The STABLE technique was demonstrated on the existing masonry building at Kunjaban through site measurement, installation and finishing.

TRAINING AND LIVE RETROFIT AT HINGOLI





Training and Capacity Building Programme
Primary School, Pangra Shinde, Vasmat Taluka, Hingoli, Maharashtra
22 September 2026

Training combined technical explanation with hands-on implementation on an existing masonry school building.

HINGOLI: LIVE RETROFIT AND COST





Approximate executed retrofit cost

₹175 per sq ft

Reported for the Hingoli demonstration. Actual cost will vary with building condition, detailing, access, local labour and finishing requirements.

The Hingoli programme combined live installation with completion of the steel twin lintel band at the existing school building.

TECHNOLOGY IMPLEMENTATION: SUMMARY

State	Demonstration building	Reported executed cost*
Uttarakhand	Residential Building C-27, CSIR-CBRI, Roorkee	**₹250/sq ft**
Tripura	Office Building, Medical College Sub-Division No. I, Kunjaban, Agartala	**₹300/sq ft**
Maharashtra	Primary School, Pangra Shinde, Vasmat Taluka, Hingoli	**₹175/sq ft**

Replication framework for trained engineers

01	02	03	04
Building screening and measured condition assessment	**Building-specific analysis, design and retrofit detailing**	**Supervised installation with material and workmanship checks**	**Completion records, cost documentation and town-level replication**

Engineering requirement: complete a building-specific assessment and obtain approved retrofit detailing before execution.

**Indicative costs depend on building condition, intervention scope, access, quantities, local rates and finishes.*

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 housing systems across India.



Innovators:

Dr. Ajay Chourasia
Dr. Shailesh K Agrawal
Prof. C V R Murty

Contributors:

Dr. Ajay Chourasia
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Mr. Jalaj Parashar
Ar. S Kavitasree
Ms. Shaina Sachdeva

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