



Engineering Resilience in Geotechnics: Case Studies and Lessons from the Field

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INDIA AND BRAZIL





ENGINEERING RESILIENCE

Ability of systems and communities to recover from natural hazards.

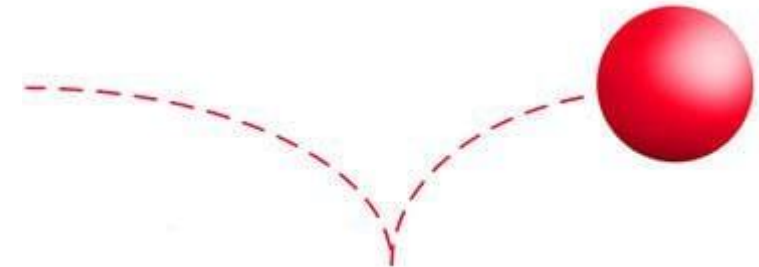
Key Elements:

- Preparedness
- Adaptability
- Timely response

Importance:

- Reduces fatalities and economic loss
- Enhances recovery and sustainability
- Builds public trust and safety

Resilience





Engineering Resilience Examples

- Earthquake-resistant buildings
- Flood control systems
- Backup power systems
- Robust communication networks that can recover quickly after disruptions





Engineering Resilience Goal

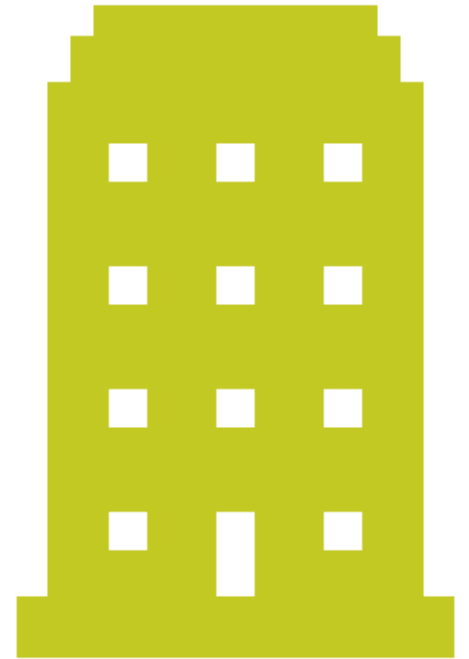


To ensure that critical infrastructure and systems can continue to function effectively, even in the face of unexpected challenges, thereby enhancing the overall stability and sustainability of communities and society.



Structural Resilience

- Structural resilience is the ability to **rapidly resume the use** of buildings and structures **following a shock** incident or event.
- To successfully do this, it is essential to embrace all the associated aspects
- Avoidance, diminution or removal of identified threats or hazards.
- Preparation for disaster event scenarios.





Climate Changes and Resilience in Structures



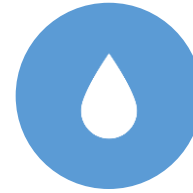
**GLOBAL
WARMING**



**TEMPERATURE
RISE**



**EXCESS RAIN
FALL**



FLOODING



CYCLONES



Devastating Floods and Importance of Resilient Engineering



High-Intensity Rainfall & Cloudbursts

- What is High-Intensity Rainfall?
 - Rainfall exceeding 100mm/hour
- Cloudburst:
 - Sudden, heavy rainfall over a small area in a short time
- Impacts:
 - Flash floods
 - Landslides
 - Infrastructure damage





Flash Flood in Central Texas

- **Catastrophic flash flooding struck Central Texas on July 4**, killing over **100 people**, including 27 girls and staff at a summer camp in Kerr County, after the **Guadalupe River surged 26 feet in just 45 minutes**.
- **Unprecedented atmospheric moisture and instability** fueled by a superheated Gulf of Mexico, created a slow-moving storm system that **dumped 2–4 inches of rain per hour**, overwhelming the region.
- **Climate change is strongly linked to this disaster**, with experts calling it a "**literal wall of water**" and noting record July moisture levels and increasingly frequent **1-in-100-year rain events** becoming more common.





High-Intensity Rainfall & Cloudbursts



- **Texas' limestone-rich terrain worsened runoff**, as shallow soils and steep slopes allowed water to rush quickly into rivers, accelerating flash flood conditions.
- **Economic damage is estimated at \$18–22 billion**, with criticisms surfacing about prior decisions to forgo a more robust flood warning system for cost reasons.
- **Despite flood alerts being issued**, many victims either didn't receive or fully understand the warnings, highlighting gaps in communication, emergency planning, and the dangers of potential NOAA budget cuts.



FLOODS 2018: KERALA

- 80,000km of roads have been damaged.
- 10,000 km of roads were washed out
- 1 lakh houses were damaged
- 26,000 houses were destroyed
- Lost 483 lives
- 365 bridges in the state requires immediate restoration
- Damages worth 20,000 crores were reported





LANDSLIDES AND FLOODS 2024: WAYANAD, KERALA

- A series of landslides occurred in the **Vythiri Taluk of Wayanad district in Kerala in July 2024**.
- This was caused by the **excessive heavy downpour in the region**.
- It resulted in the **hillsides to collapse**, sending **torrents of mud, water, and boulders** crashing down onto the affected areas.
- The official records report of over **420 fatalities, 397 injuries, and more than 118 people still missing**.
- The debris flow originated at an **elevation of 1,544m**.





LANDSLIDES AND FLOODS 2024: WAYANAD, KERALA





LANDSLIDES AND FLOODS 2024: WAYANAD, KERALA





Post-Landslide Rehabilitation Initiatives – Mundakkai & Chooralmala

- **Model Township Development**

Kerala Govt approved & commenced a scaled township at Elstone Estate (~64 ha) after HC's order—first homes (99) are roofed and constructed as of May 2025.

- **1,000 sq ft Housing Units TK infrastructure plan:**

1,000 sq ft single & double-storey homes via KIIFB in two phases (~Rs 750 cr)

- **Land Acquisition & Legal Approvals**

HC cleared acquisition of Harrisons & Elstone estate lands under Disaster Management Act; fair compensation ensured

- **Financial Support & Community Amenities**

Daily living allowances (~₹300/month renewed up to 9 months) during reconstruction

- **Engineering & Relief Partnerships**

Uralungal LCCS appointed as contractor; multiple private & NGO agencies (HIF India, Viswasanthi, Sobha, etc.) built houses (35+ handed over) and supported special facilities.

- **Community Empowerment & Livelihood Support**

Job fairs held by local engineering associations; 14 small businesses granted seed funding to rebuild local economies.



Rehabilitation & Future Early Prediction

Post-disaster rehabilitation:

- Temporary shelters
- Rebuilding with climate-resilient infrastructure

Future strategies:

- Satellite-based rainfall prediction
- IoT sensors for real-time monitoring
- Community-level training and awareness



Massive Landslide Prediction Technologies

Emerging Tools:

- Remote sensing + LiDAR
- Ground Movement Radar (InSAR)
- AI for historical pattern analysis

Key Benefits:

- Predict potential slip zones
- Evacuation planning
- Cost-effective monitoring



AI/ML in Soil Analysis & Drilling

Traditional Drilling Limitations:

- Time-consuming, costly
- Labor-intensive AI & ML

Advances:

- Predictive soil modeling using geospatial and sensor data
- Strength condition predictions using historical datasets
- Real-time alerts for vulnerable terrain



Engineering Resilience in Building Demolition by Implosion





Key Elements of Engineering Resilience in Implosion:

1. Pre-demolition Assessment:

- Structural integrity analysis
- Soil and surrounding building impact studies

2. Controlled Collapse:

- Computer simulations to predict collapse pattern
- Redundancy and safety factors built into sequencing

3. Blast Containment & Safety:

- Barriers, dust control systems
- Evacuation and emergency response plans

4. Post-Demolition Recovery:

- Rapid debris clearance
- Site reuse planning (e.g., green spaces, reconstruction)



Importance of Engineering Resilience in Implosion:

- Minimizes unintentional damage to adjacent structures
- Protects urban infrastructure and human safety
- Enhances confidence in large-scale redevelopment projects

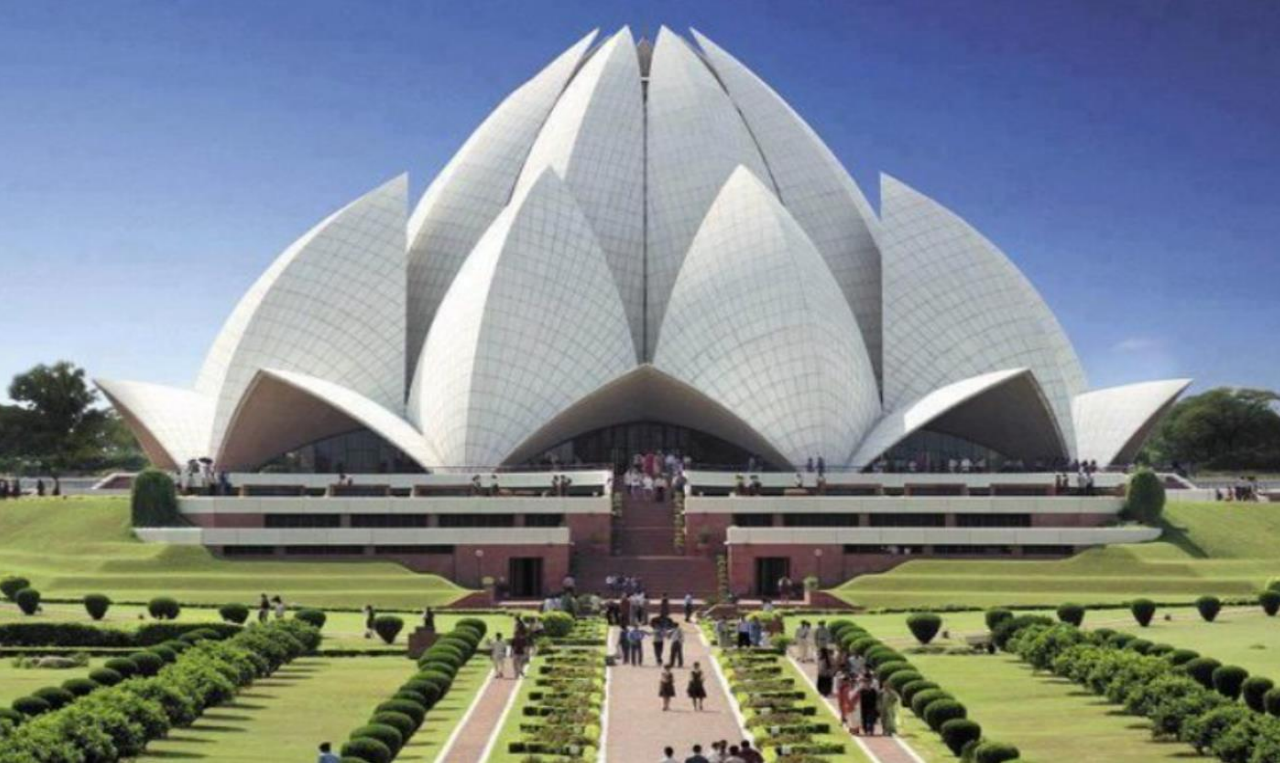


Technology Involvement

- 3D structural modeling
- Vibration analysis using sensors
- AI for blast timing and damage prediction



Demolition by Delayed Detonation Technique: Supertech Twin Tower Noida, India





DEMOLITION OF BUILDING BY IMPLOSION

- Implosion is a controlled demolition technique where load-bearing structures are collapsed inward using strategically placed explosives.
- The technique weakens or removes critical supports so that the building can no longer withstand the force of gravity and falls under its own weight.

Controlled Implosion, Step by Step



STEP 1

Survey surrounding areas to determine if structure should fall to one side or collapse on itself



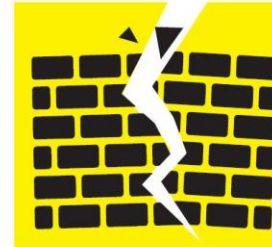
STEP 2

Study building plan to see where explosives can be placed



STEP 3

Remove toxic substances like asbestos, flammable materials, glass and furniture



STEP 4

Remove non-load bearing walls



STEP 5

Drill holes in columns and place explosives, cover columns with geotextiles



STEP 6

Detonate

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VIBRATION MEASUREMENT IN CONSTRUCTION INDUSTRY

- Vibration measurement plays a crucial role in the construction industry for several reasons.
- Monitoring vibrations during construction/ deconstruction processes is essential to ensure the safety, structural integrity, and efficiency of both construction activities and the surrounding environment.
- The influence of vibration on surrounding structures is one of the most important factors considered during blasting demolition of high-rise buildings in metropolitan regions



VIBRATION MEASUREMENT IN CONSTRUCTION INDUSTRY

- The ground motion caused by blasting demolition is usually a combination of blasting vibration, backlash vibration and touch down vibration and it could damage nearby structures if the amplitude of these vibrations are high.
- Vibration measurement is critical during the implosion process to monitor the impact of the explosive forces on nearby structures, ensuring safety and minimizing collateral damage.



Relation of damage to adjacent buildings due to vibration velocity

Maximum velocity of mass point(mm/s)	Damage level
35	None
55	Slight cracking/desquamation
80	Cracking
115	Severe cracking



IMPLOSION FAILURES





IMPLOSION SUCCESS





ABOUT SUPERTECH TWIN TOWER, NOIDA

- Located in Sector 93A, Noida, near the Noida–Greater Noida Expressway
- Comprised of two towers: Apex and Ceyane
- Initially planned with 40 floors each

Final structure:

- Apex: 32 floors, 103 m (338 ft) tall
- Ceyane: 29 floors, 97 m (318 ft) tall
- Combined built-up area: 7.5 lakh sq. ft

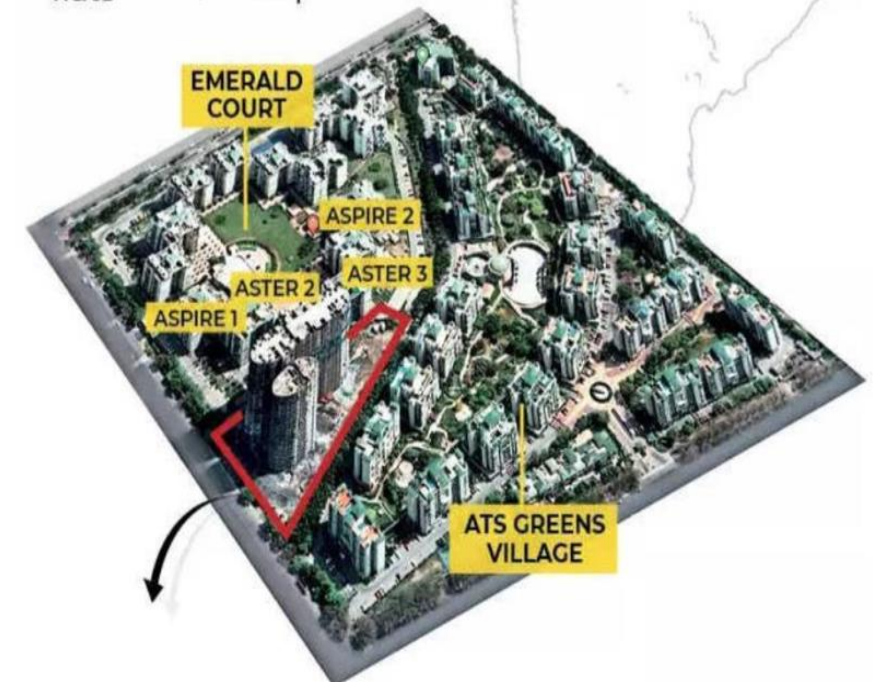
THE PROJECT

Total built-up area

7 lakh sq ft

915 | **21**
flats | shops

Sector 93A,
Noida, UP





BACKGROUND & TIMELINE

SUPERTECH TWIN TOWER, NOIDA

- **2005:** Noida Authority approved construction of Emerald Court (14 towers, G+9); in 2006, area increased to 54,819.51 sq. m
- **2006–2012:** Plan modified—2 more towers added; height revised from G+11 to 40 floors
- **Dec 2012:** RWA filed case in Allahabad High Court
- **Apr 2014:** High Court declared towers illegal, ordered demolition; construction halted
- Apex: 32 floors, 103 m, 41,720 tonnes
- Ceyane: 28 floors, 94 m, 18,150 tonnes
- 633 flats were booked, but towers remained uninhabited
- **Aug 2021:** Supreme Court ordered demolition citing illegal construction & distance violations
- **Jan 2022:** Edifice Engineering & Jet Demolitions appointed for execution



ENGINEERING CHALLENGES BEHIND DEMOLITION





ENGINEERING CHALLENGES BEHIND DEMOLITION

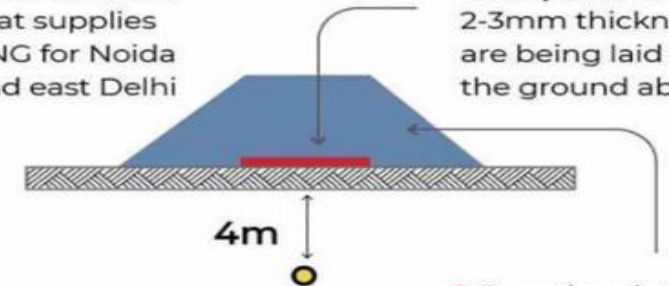
- Located in a **densely populated area**, surrounded by **Emerald Court and ATS Village (high-rise complexes)**
- Towers **initially shared basement & foundation with Emerald Court**, separation before demolition was complex
- **Aster 2 building** lies just **9 meters away** from the **Twin Towers**
- **Underground gas pipeline** runs through the tower site
- Demolition had to **avoid damage to nearby structures**
- **Plan designed to make towers collapse into open space near ATS Village**

UNDERGROUND GAS PIPELINE

● This pipeline is 4 metres below the ground at a distance of 16 metres from the towers

● The pipeline is a crucial one that supplies CNG for Noida and east Delhi

● To protect it, **steel plates** of 2-3mm thickness are being laid on the ground above



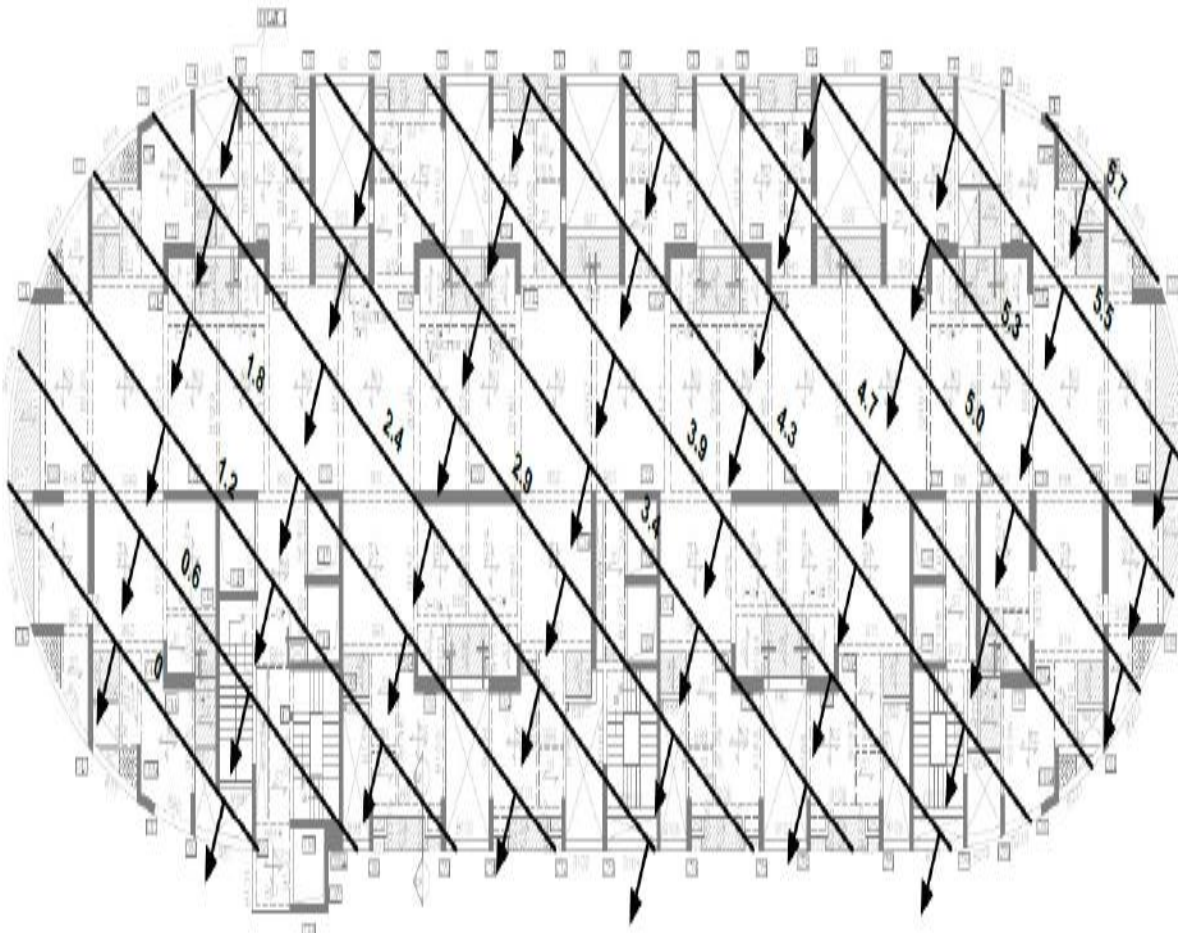
● The steel plates and protection berms will span across the entire 150-metre length of the pipeline that needs to be protected

● Over the plates will be '**protection berms**' with a 1.5-metre rubble filling for double insulation





TYPICAL IMPLOSION ISOCHRONONE LAYOUT



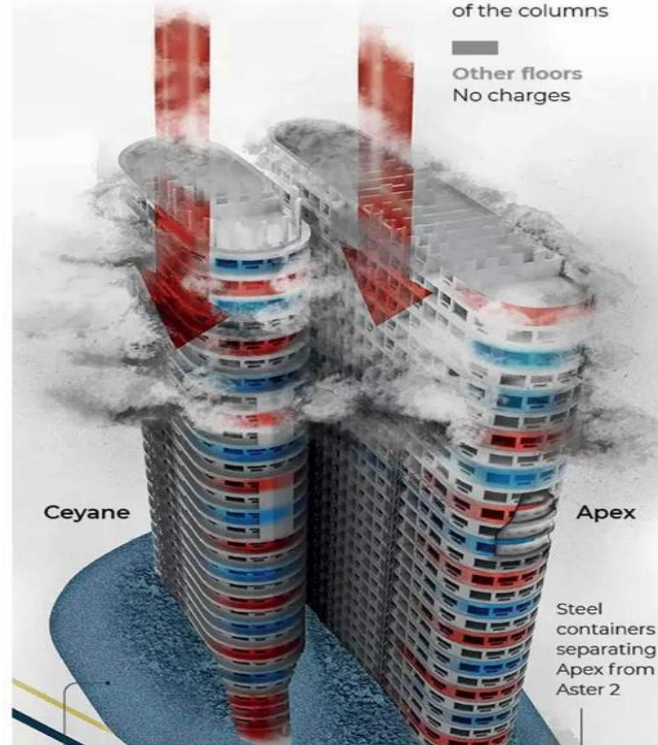


PREDICTED DEBRIS SPREAD FOR SUPERTECH TWIN TOWER BY EDIFICE ENGINEERING -MUMBAI

7 STAGES OF THE BLAST

-  **THE SKETCHBOOK:** Drawing the plan based on the towers' design, factoring in distance from nearby buildings, the strength of the twin towers and type of construction material used
-  **HAMMER & TONGS:** Stripping the towers' floors to beams and columns, removing extra concrete
-  **THE STASH PIT:** Creating impact cushions in the basement using the debris generated. No debris has been taken out of the twin towers compound
-  **BURROWING IN:** Drilling 9,642 holes in the shear walls for explosives. If they were to be placed in a row, the length would be 16.74km. The diameter of each hole is 35mm
-  **TAKING COVER:** Wrapping the shear walls and floors with iron mesh (collectively weighing 225 tonnes) and geotextile cloth (collectively, 110km in length)
-  **CHARGING IT UP:** Placing explosives in the shear walls, a process called 'charging' that begins on August 2 and goes on till August 27, as explosives are brought in instalments from a PESO- authorised magazine in Palwal
-  **LETTING IT RIP:** Connecting the detonator to the charges on Aug 28, before the button is pressed at 2.30pm

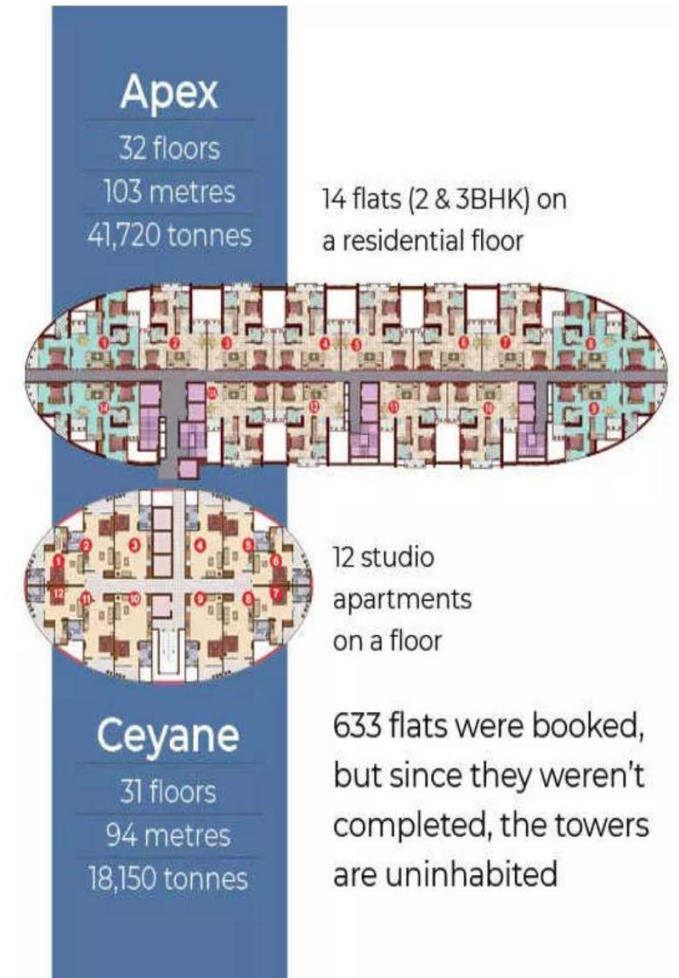
● **Ceyane and Apex will come down simultaneously.** Charges will be triggered in a cascade, bottom to top, at a gap of 1 second each, which will get the floors to collapse in a series. The buildings will come down in **9 seconds**



Primary blast floors
Charges will be placed in all columns

Secondary blast floors
Charges in 40% of the columns

Other floors
No charges





ASSESSMENT OF NEARBY BUILDINGS AND TEST BLAST

- Conducted **pre- and post-blast** structural surveys of nearby buildings
- Analyzed vibration impacts from tower collapse using Etabs Model
- Focused on nearby buildings:
 - 3 towers in Emerald Court (Supertech-maintained)
 - 4 towers in ATS Village (maintained by Colliers)
- Performed a **Rapid Visual Assessment (RVA)** to evaluate structural integrity
- Submitted a detailed inspection report based on site findings



ASSESSMENT OF NEARBY BUILDINGS AND TEST BLAST





ASSESSMENT OF NEARBY BUILDINGS AND TEST BLAST

After the contract for the demolition was signed in January, the preparations for the demolition work started in early February.

Key preparatory steps:

- Structural assessment of Twin Towers and nearby buildings
- Basement disconnections between towers and adjacent Supertech buildings
- Manual removal of dead weight (non-structural elements) to expose the bare frame for demolition



ASSESSMENT OF NEARBY BUILDINGS AND TEST BLAST





SAMPLE OF CRACK WIDTH ASSESSMENT

PRE-BLAST VISUAL INSPECTION REPORT

Doc.No.: M/GS/2022/EC_A3_ANNEXURE_B/2

11. Apartment No.: 503

Table 1: Summary of Cracks

SUMMARY OF CRACKS SEEN DOCUMENTED DURING RAPID VISUAL TEST						
ASTER-3 Apartment No.- 503						
Defect ID	Location	Orientation	Approx. Width	Approx. Length	Category	Photo ID
1	Balcony	Vertical	0.40 mm	1.00 m	Very Slight	503-01
2	Bed room	Vertical	0.10 mm	0.50 m	Negligible	503-02
3	Balcony	Horizontal	1.00 mm	0.60 m	Slight	503-03
4	Bedroom	Vertical	0.30 mm	0.20 m	Very Slight	503-05
5	Balcony	Horizontal	1.00 mm	1.50 m	Slight	503-07

Table 2: Summary of Defects Other Than Cracks

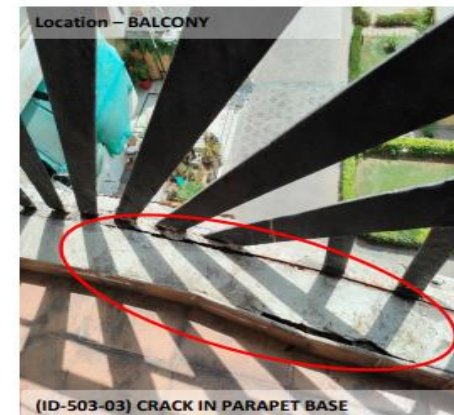
SUMMARY OF DEFECTS OTHER THAN CRACKS SEEN DOCUMENTED DURING RAPID VISUAL TEST			
ASTER-3 Apartment No.- 503			
Defect ID	Location	Description	Photo ID

PRE-BLAST VISUAL INSPECTION REPORT

Doc.No.: M/GS/2022/EC_A3_4A503/066_R1

7. Observations

During the time of inspection some cracks and other damages were observed on various parts of the apartment.



NDT TESTS PERFORMED

Images of Testing at Site:





METHODOLOGY

- To analyze the impact of blast induced vibration on the neighboring buildings due to the demolition of Supertech twin tower, Aster-2 RCC structure which is the nearest structure to the twin tower is expected to have the maximum impact.
- The aster 2 tower is modelled in ETABs with the available drawings of the structure. The peak particle velocity maximum likely to happen within a radius of 10m at the time of blast is 34mm/s as in the report provided by Vibrock was taken into consideration.
- The acceleration v/s Time history curve corresponding to this peak particle velocity of 34mm/s was used to perform time history analysis to study the blast.
- The model with blast load vibration is compared with the model with earthquake loads

Maximum Acceleration: 43.362cm/sec²
at time t=24.620sec

Maximum Velocity: 6.834cm/sec
at time t=24.740sec

Maximum Displacement: 19.975cm
at time t=23.730sec

V_{max} / A_{max}: 0.158sec

Acceleration RMS: 6.370cm/sec²
Velocity RMS: 1.845cm/sec
Displacement RMS: 10.109cm

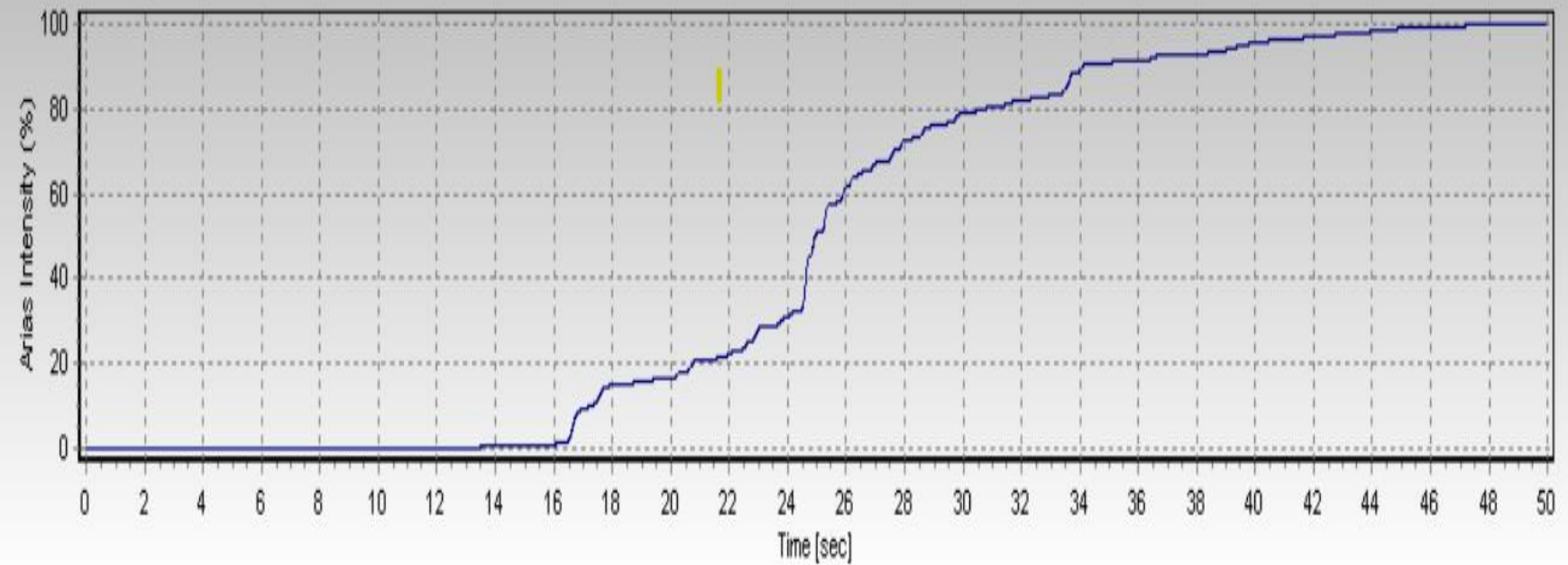
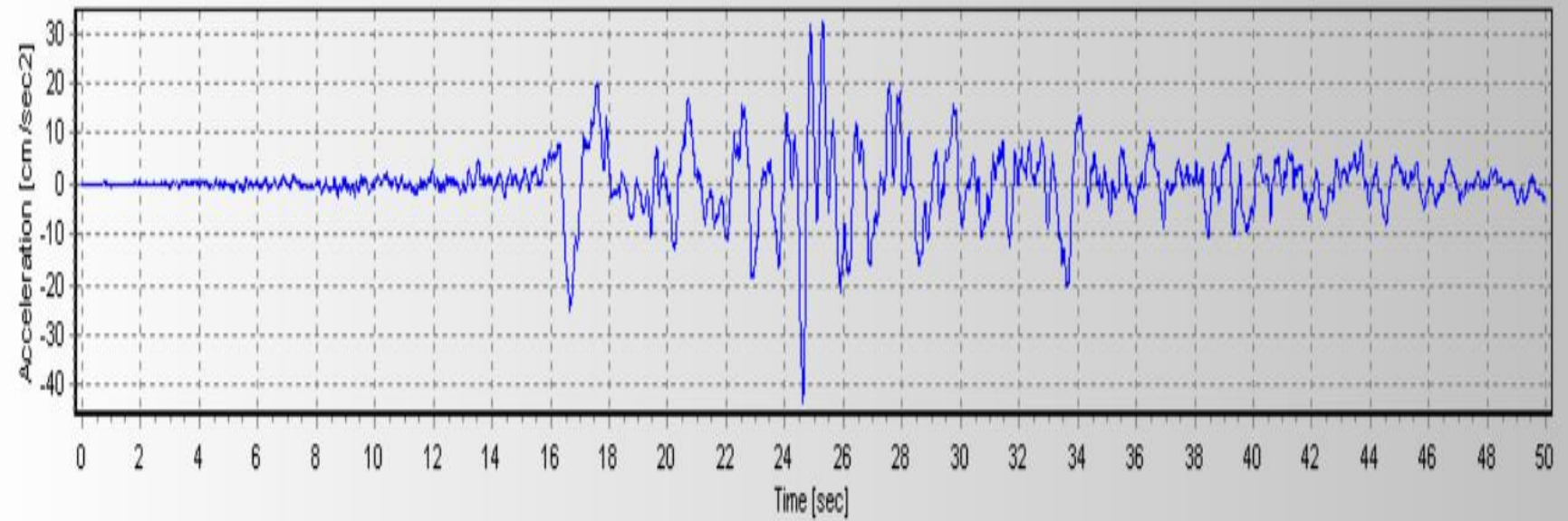
Arias Intensity: 0.032m/sec
Characteristic Intensity (I_c): 113.692
Specific Energy Density: 170.114cm²/sec
Cumulative Absolute Velocity (CAV): 192.757cm/sec

Acceleration Spectrum Intensity (ASI): 31.556cm/sec
Velocity Spectrum Intensity (VSI): 28.609cm
Housner Intensity: 29.162cm

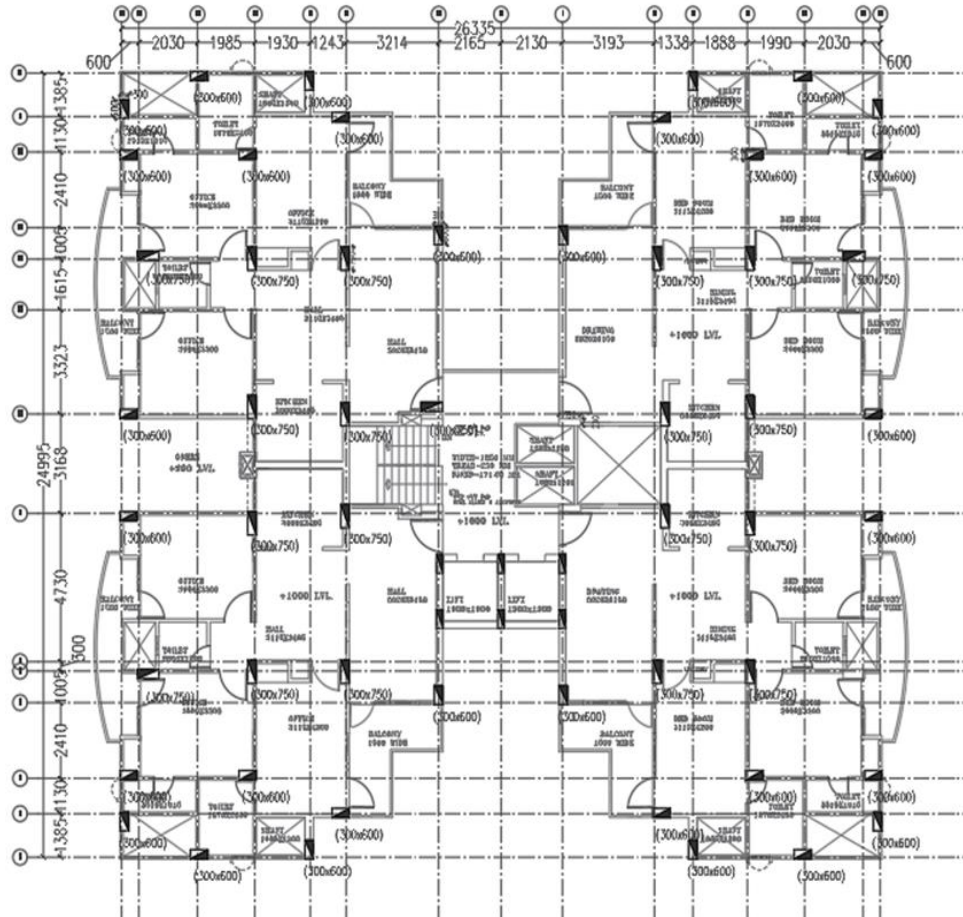
Sustained Maximum Acceleration (SMA): 31.850cm/sec²
Sustained Maximum Velocity (SMV): 5.522cm/sec

Effective Design Acceleration (EDA): 42.521cm/sec²

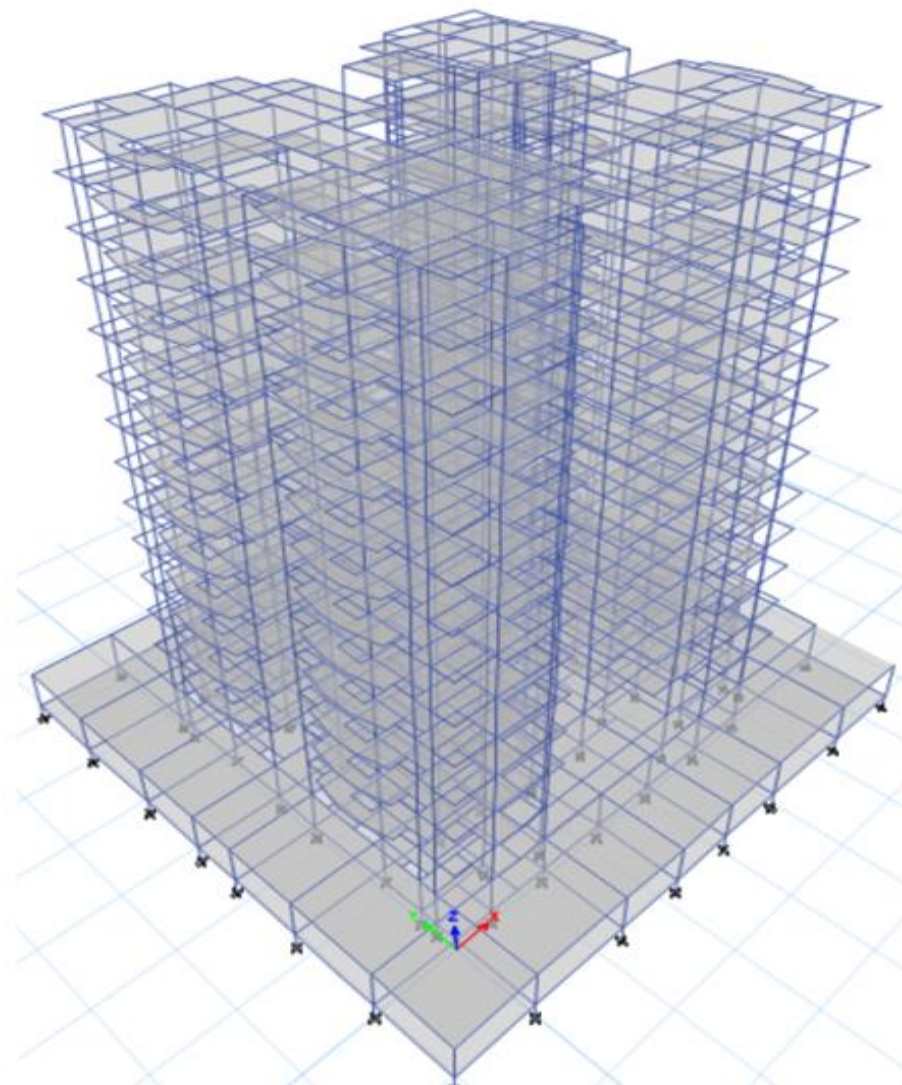
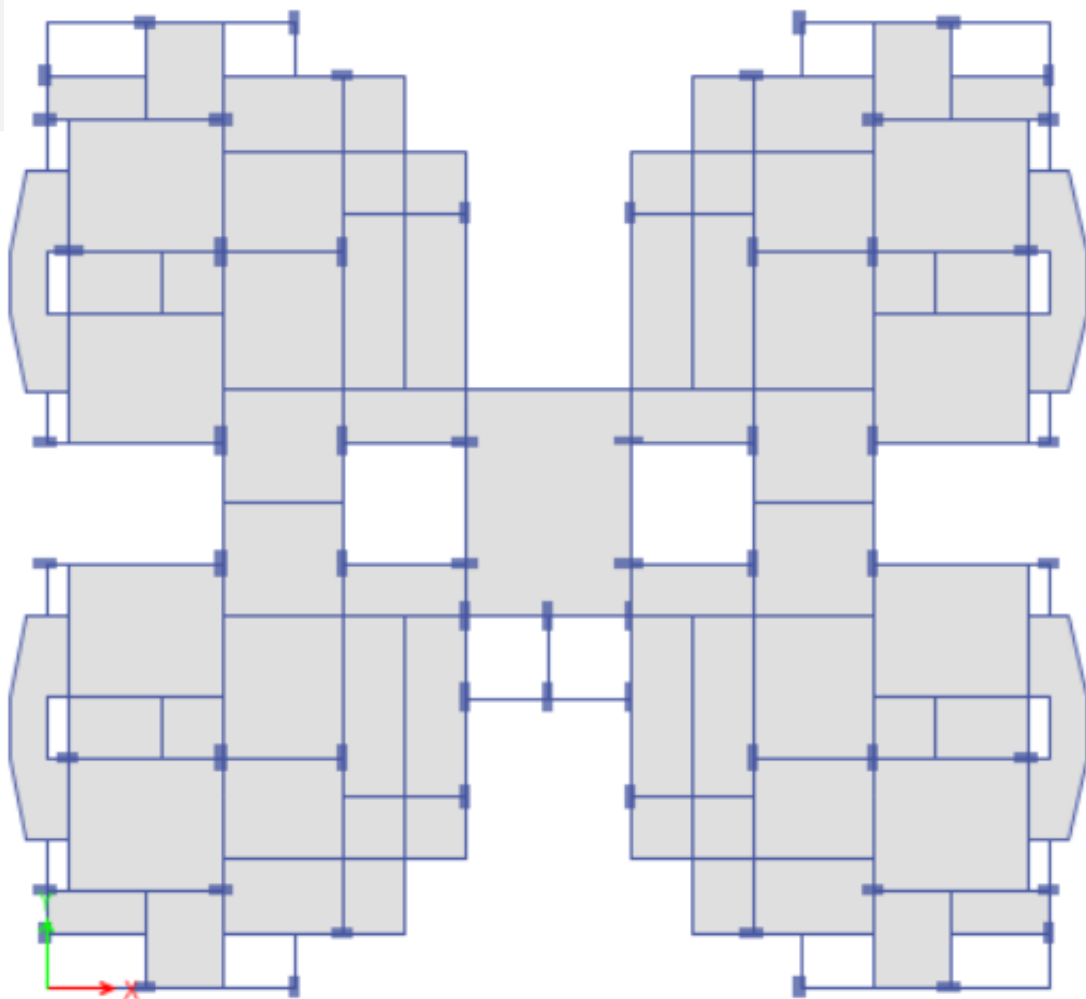
A95 parameter: 42.596cm/sec²



ABOUT THE STRUCTURE - “ASTER-2”

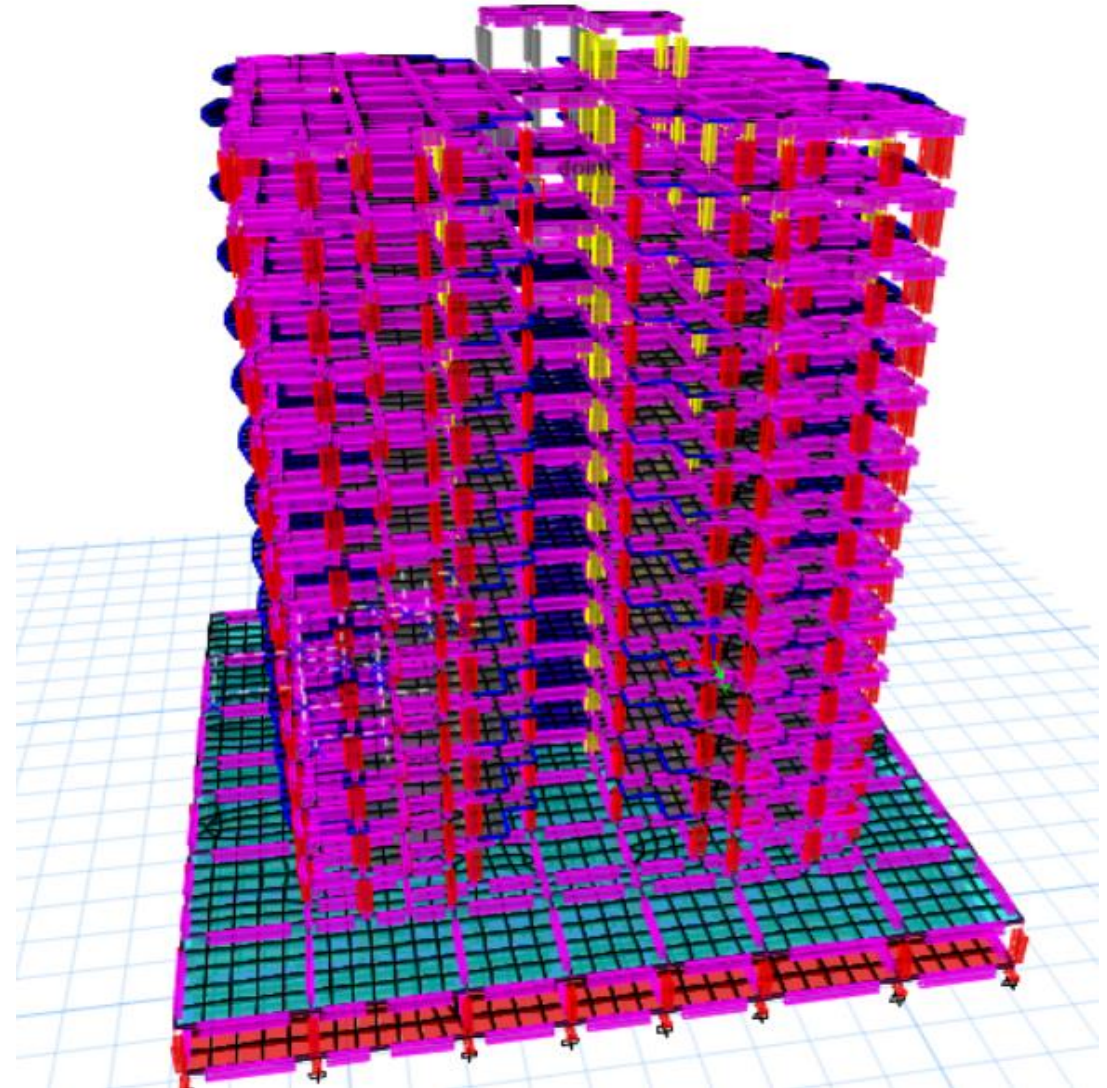
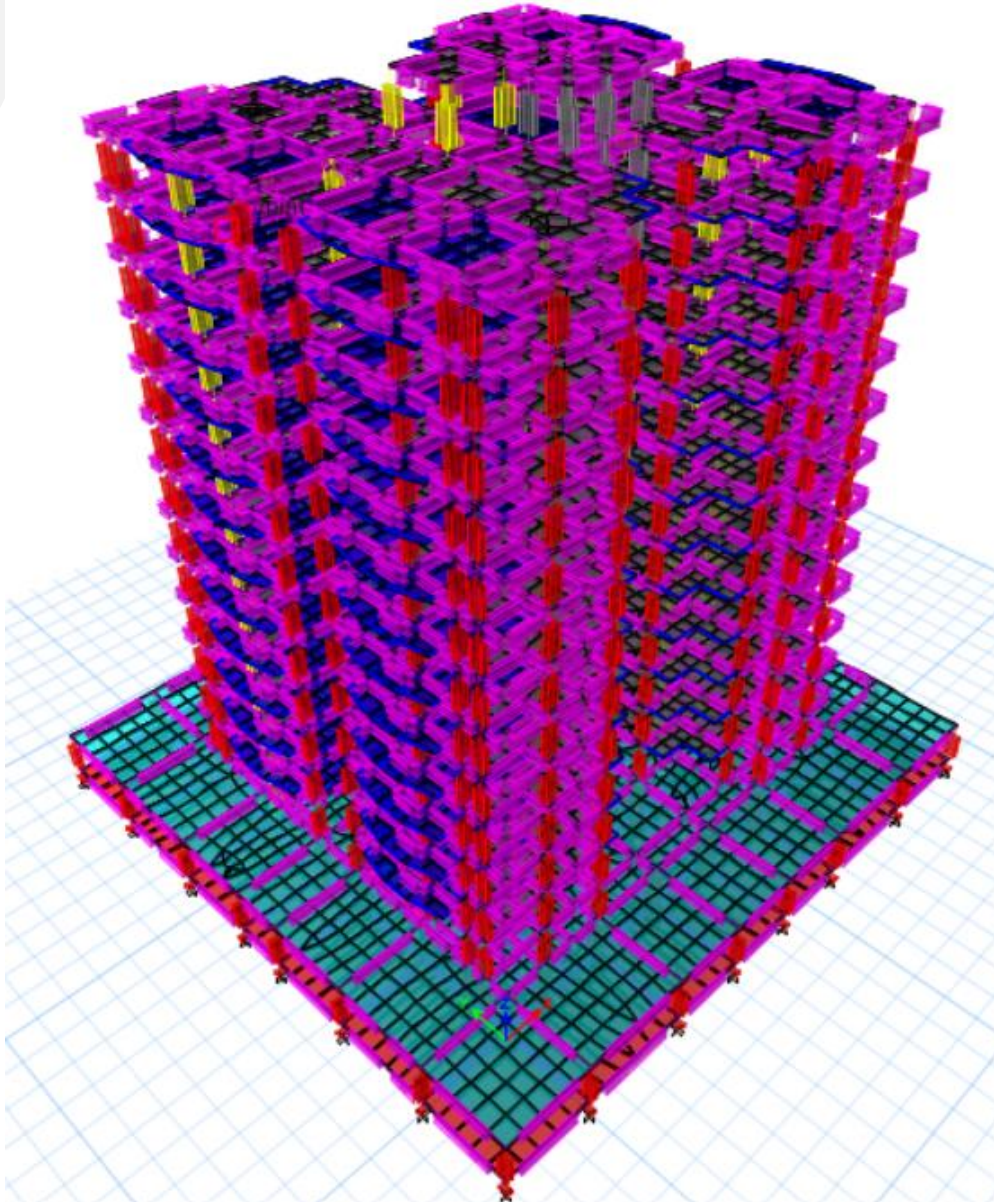


- Consists of basement + ground + 12 floors + terrace
- Basement floor consists of Parking area
- Typical floor consists of 4 Apartments (Ground floor to 12th floor)
- The average compressive strength of rebound hammer test performed in the neighboring towers is 25.2 Mpa.
- Framed structure with Columns are the primary vertical structural members.
- Conventional beams and slab system for floors
- Foundation- Raft



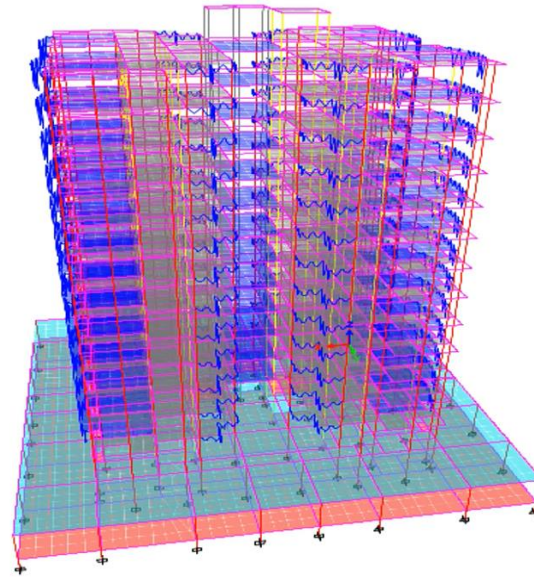


ASTER 2 BUILDING MODEL IN ETABS



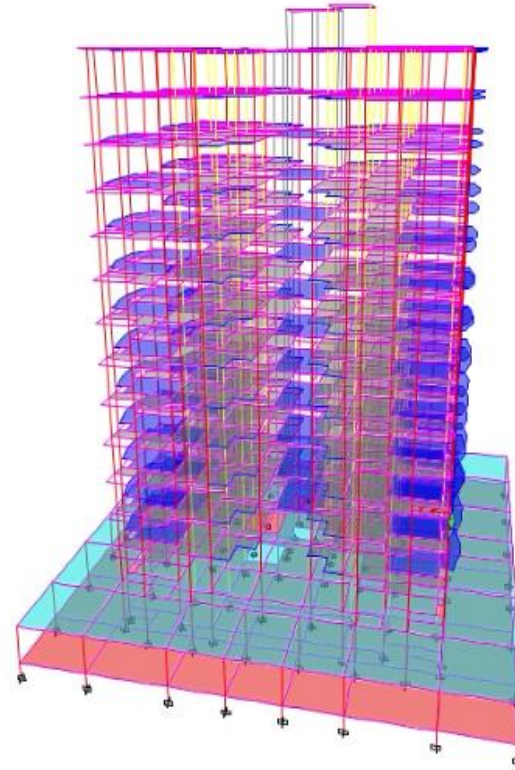


EARTHQUAKE LOADING ANIMATION





BLAST LOADING ANIMATION





RESULTS OF ANALYSIS

- The analysis of the two models showed that impact caused by controlled blast loading is feeble when compared with the earthquake loading.
- The maximum peak particle velocity predicted in the report by Vibrock is 34mm/s which falls within the range of no damage.
- The storey displacement for blast loading falls within the limit of permissible storey displacement as per IS 1893 part1 2016
- The base shear force for blast loading is nearly half of that caused by earthquake loading
- It could be concluded that there is no considerable impact on the neighbouring buildings for the blast loading



MEASURING GROUND VIBRATIONS

- A Nine member team from GeoStructurals and IIT Madras was tasked to measure the ground vibrations due to demolition of these Apartment Complexes
- Vibration measurements were done using accelerometers, geophones, etc.
- The ground vibrations measuring team were with 100m of the blasting zone as the cable lengths available for these accelerometers were ranging from 50metres to 200 metres.



Layout of accelerometers and geophones placed for measurements





POSTIONING AND CONNECTIONS





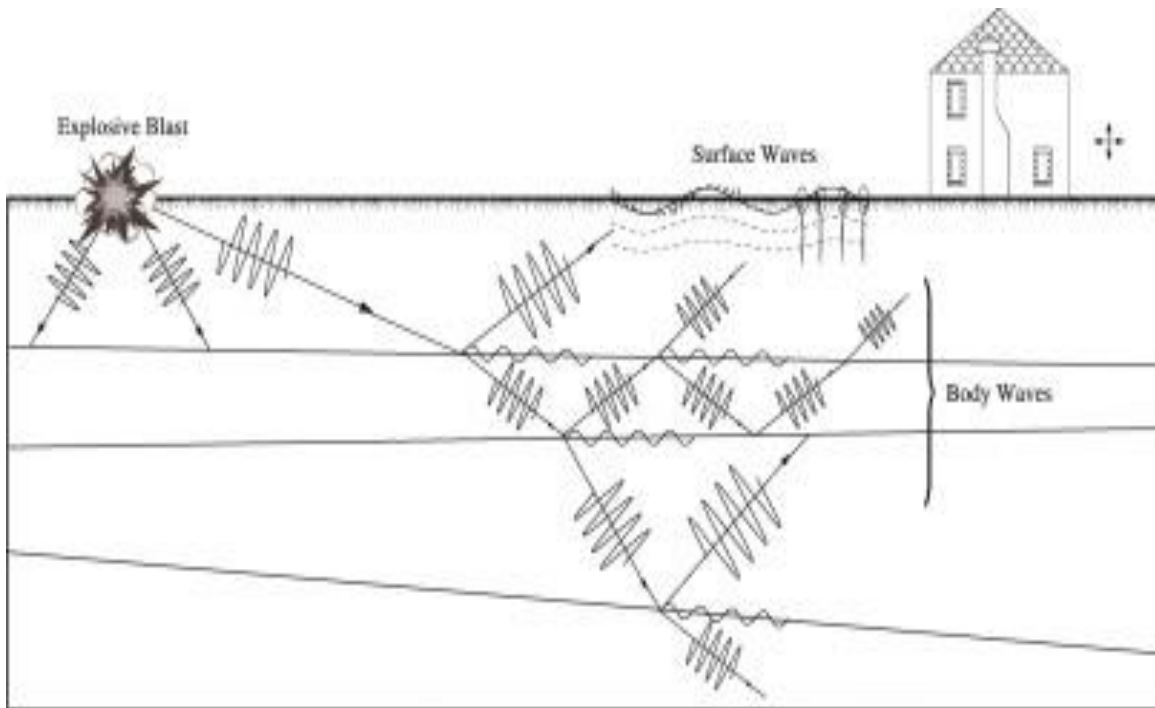
MEASURING GROUND VIBRATIONS

- Accelerometers were installed on top of the GAIL gas pipeline, while geophones were positioned 33 - 62m from the twin tower building's plinth edge and 3 m below ground level in the basement.
- Due to the equipment being damaged by the fall of buildings, one of the accelerometer data was lost.
- The readings from other accelerometers placed over the GAIL gas pipeline show peak particle velocity varies from 20.4 mm/s to 24.8 mm/s.



Controlled Demolition effects on Nearby Buried Structure

- Transient ground vibrations generated during building implosion pose risks to critical buried infrastructure.



Ground vibrations propagate through soil as body and surface waves, which can induce stresses in nearby buried infrastructure.

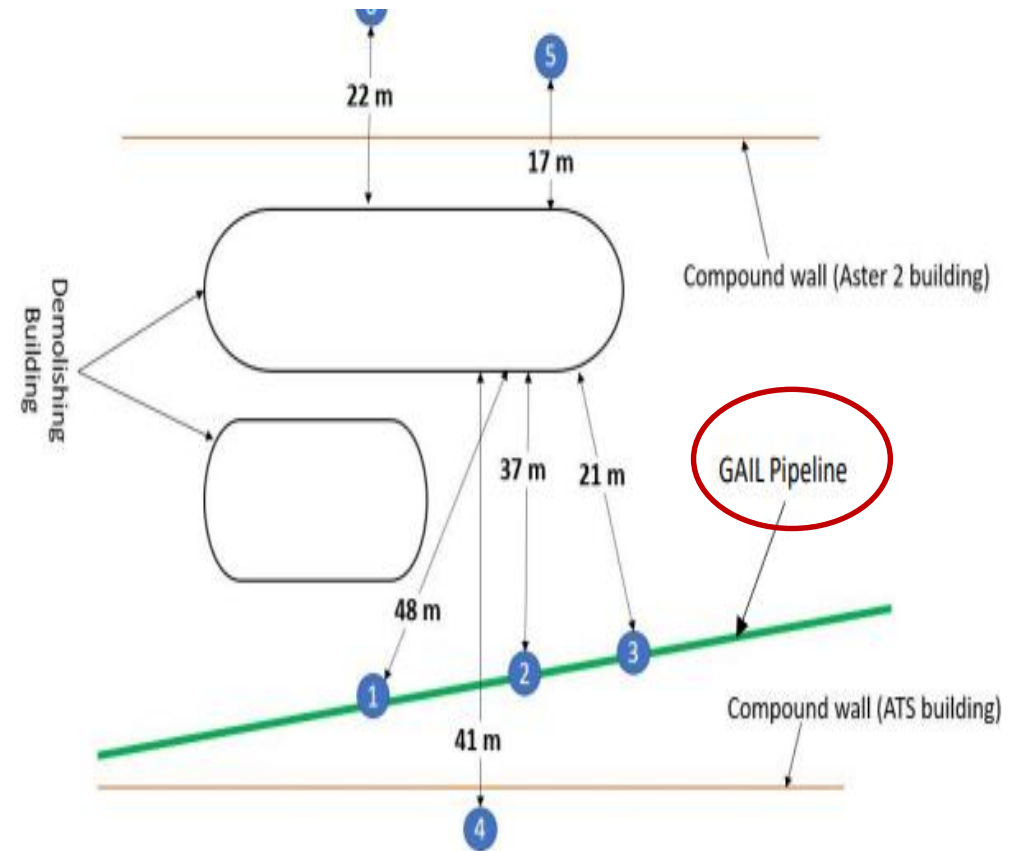
Shallow-buried pipelines are particularly susceptible to dynamic amplification, ovaling, and local buckling. Vibration effects are influenced by distance, wave frequency, soil stiffness, and burial depth.

In layered or heterogeneous soils, differential wave transmission can result in non-uniform deformation along the pipeline alignment.



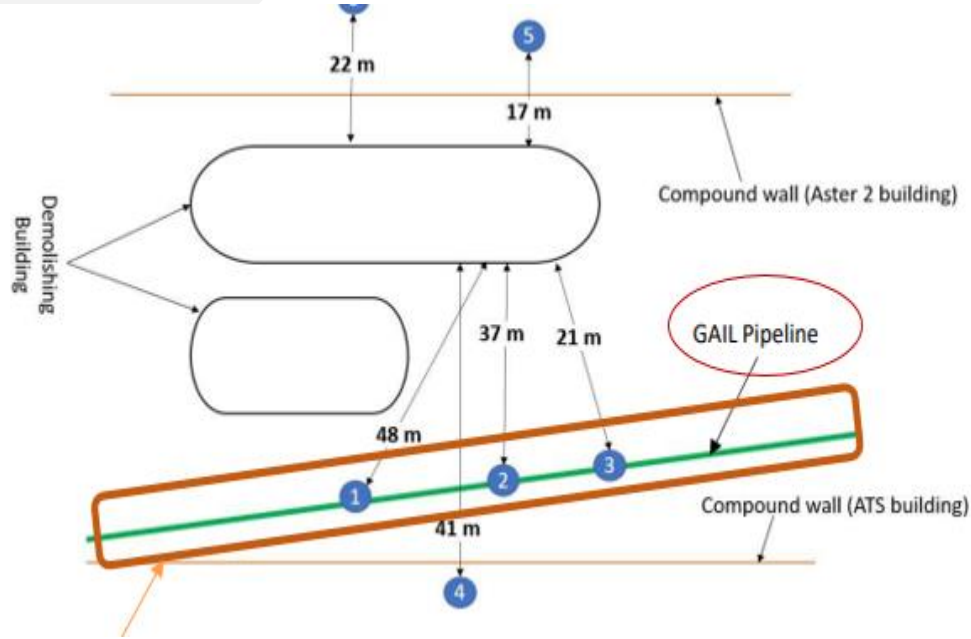
Impact of Demolition on Buried Gas Pipeline Near Demolition Zone

- **Focus:** A pressurized pipeline buried at a shallow depth of 4.0 m and located 20–30 m from the collapse zone, during the controlled demolition of the Supertech Twin Towers in Noida, India.
- The pipeline buried at a shallow depth of 4.0 m and horizontally offset by 20 to 30 m from the demolition footprint.
- Due to its proximity and low burial depth, the pipeline is susceptible to damage from transient ground vibrations and dynamic amplification effects.
- **Primary objective:** Assess the effectiveness of a vibration isolation barrier using finite element modeling for protection of the pipeline





Pipeline Protection system

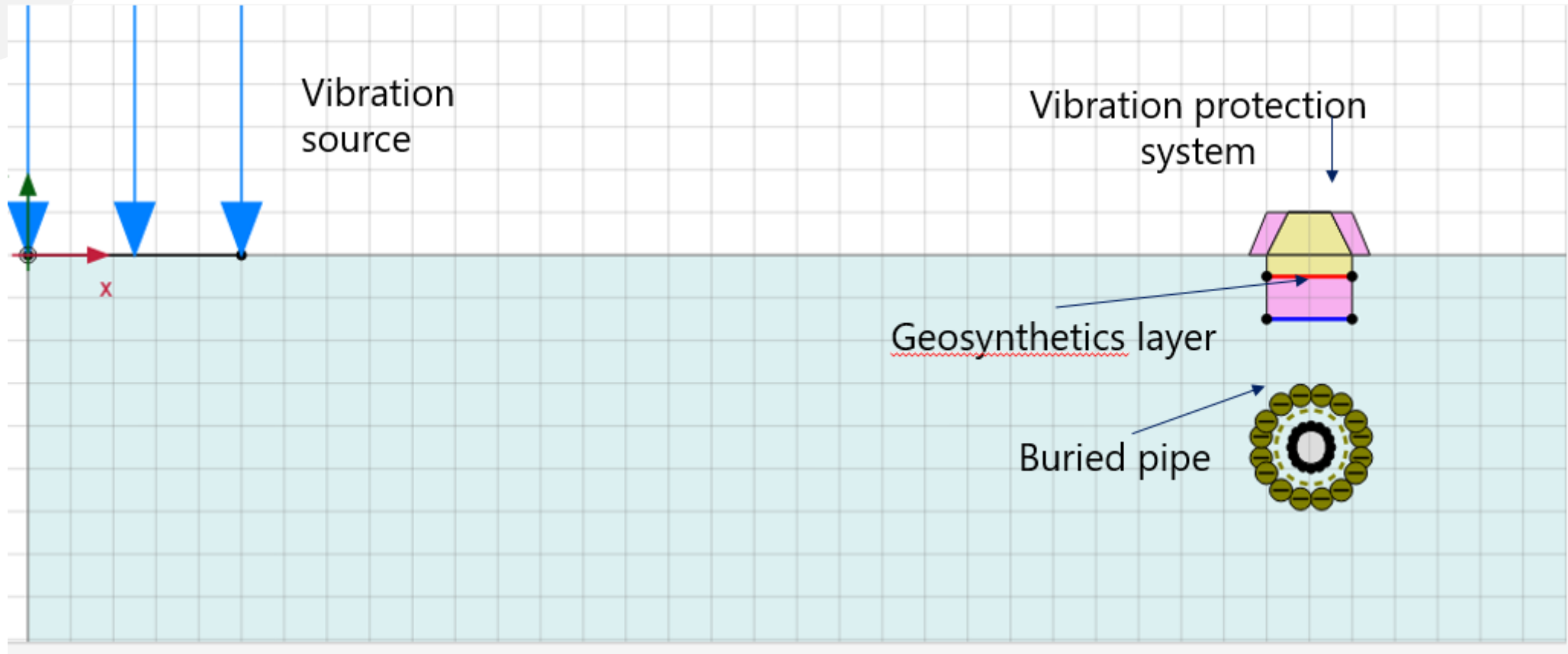


Pipeline protection system

- To protect the shallow gas pipeline from blast vibrations:
- A layered safety system was proposed to be installed in a 3 m wide trench above the pipeline made of:
- Rubber Pad – absorbed shock and cushioned the vibration
- Geosynthetics – held layers in place and added stability
- Rubber Crumb Fill – scattered the energy to reduce direct wave impact
- Thin Steel Plate (bottom) – helped spread stress evenly under the system



Finite Element Simulation of Buried Pipeline



Developed a 2D plane strain dynamic model in PLAXIS 2D with domain size: 120 m (width) $\times$ 30 m (depth)



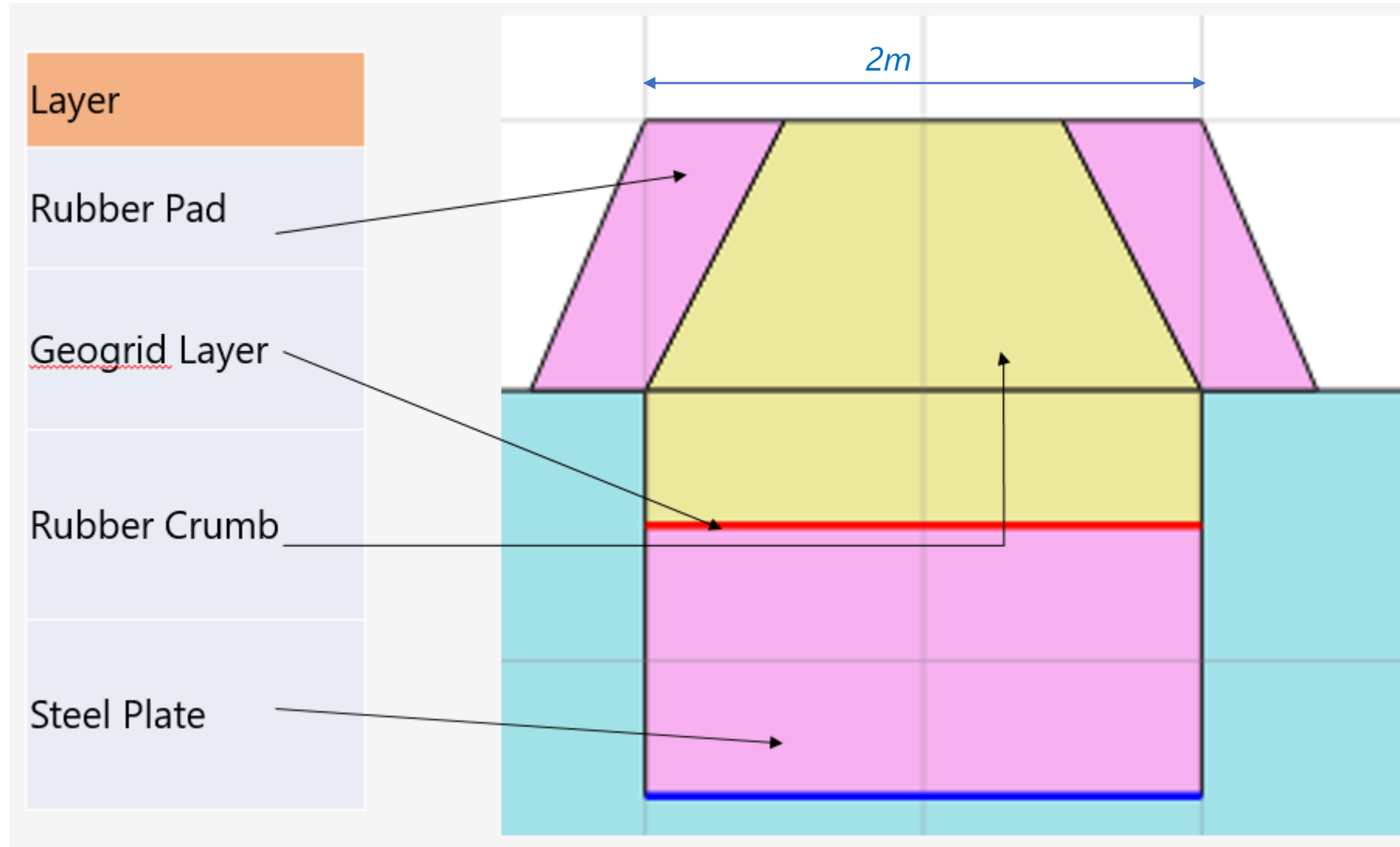
Finite Element Simulation of Buried Pipeline



- Pipeline modeled as circular volume element: - Outer diameter: 1.0 m, wall thickness: 0.1 m-16-sided polygon approximation - Pipe assigned linear elastic concrete properties: - $E = 30 \text{ GPa}$, $\nu = 0.2$, $\gamma = 25 \text{ kN/m}^3$
- Soil modeled using Mohr-Coulomb parameters; fine mesh used near pipeline and loading zone.
- Interface elements provided around pipe perimeter to simulate realistic slip and shear transfer



Protective Barrier Configuration





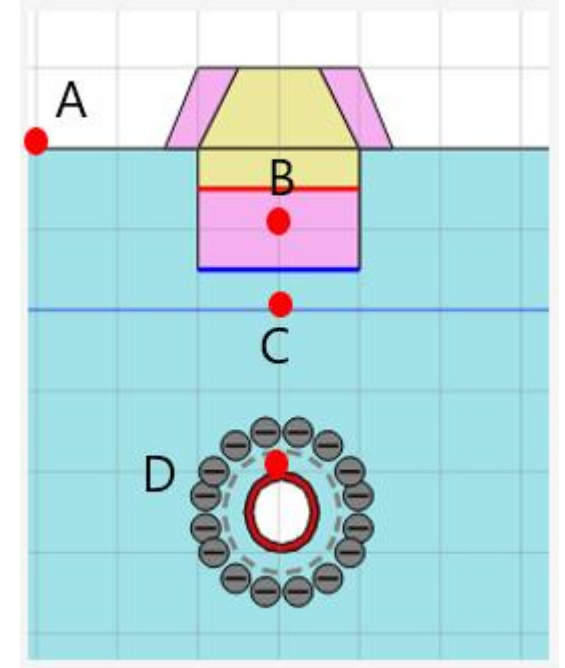
Protective Barrier Configuration

Layer	Material Model	Properties & Function
Rubber Pad	Linear Elastic (strains induced by vibration are small and vibration is short duration)	$E = 2.5 \text{ MPa}$, $\nu = 0.42$, $\gamma = 15 \text{ kN/m}^3$ Rayleigh damping parameters (High damping ratio (~10%), absorbs transient stress waves)
Geogrid Layer	Geogrid Interface	$EA = 120 \text{ kN/m}$, Pull-out stiffness = 5 MN/m^3 Provides in-plane tensile strength and separation
Rubber Crumb	Soft Soil Model (behave quasi-linearly within small strain limits)	$E_{so} = 1.5 \text{ MPa}$, $E_u^r = 4.5 \text{ MPa}$, $OCR = 1.2$, $\gamma = 10 \text{ kN/m}^3$, $\nu = 0.4$; Rayleigh damping parameters Creates impedance mismatch, effective for wave scattering and damping
Steel Plate	Linear Elastic	$E = 200 \text{ GPa}$, $\nu = 0.3$, $\gamma = 78.5 \text{ kN/m}^3$ Acts as a rigid interface, ensuring full contact between soil and protection stack



Predicted PPV at Pipeline Locations

Location Point	Position Relative to Protection Trench	PPA (m/s ²)		PPV mm/s		Remarks
		Without protection	With protection	Without protection	With protection	
Point A	Just Before Protection Trench	0.420		45.3		Represents peak input without vibration mitigation
Point B	At Mid-layer Interface (rubber–geogrid contact)	0.235	0.118	42.3	33.1	Reflects partial attenuation within the protection system
Point C	At Trench Base (just above pipeline crown)	0.213	0.085	35.6	23.1	Wave partially damped by layered medium, nearing pipeline level
Point D	At GAIL Pipeline (beneath trench)	0.162	0.065	29.7	12.2	Shows dampened wave transmission due to protection system



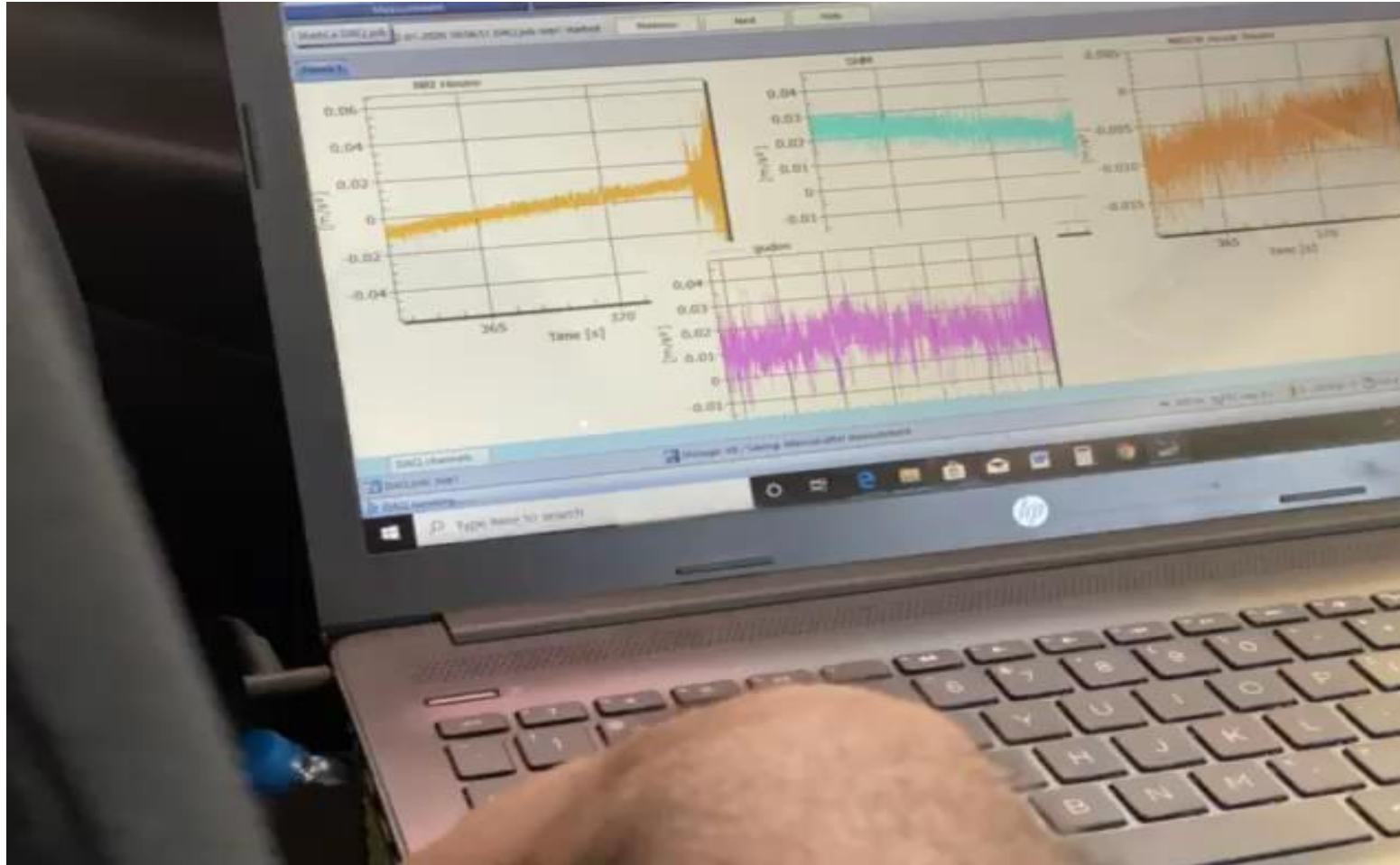


Vibration Mitigation Performance

- The proposed protection system (rubber pad, geogrid, and rubber crumb) significantly reduced vibration transmission to the pipeline.
- Quantitative Reductions:
 - ✓ Peak Particle Acceleration (PPA) reduced by over 50% at key locations.
 - ✓ Peak Particle Velocity (PPV) reduced by 60–76%, with the highest attenuation observed directly at the pipe line
- **The protection system was successfully implemented during the Supertech Twin Towers demolition.**
- Proven to be a scalable, field-tested solution for urban infrastructure protection during controlled demolitions or blast events.

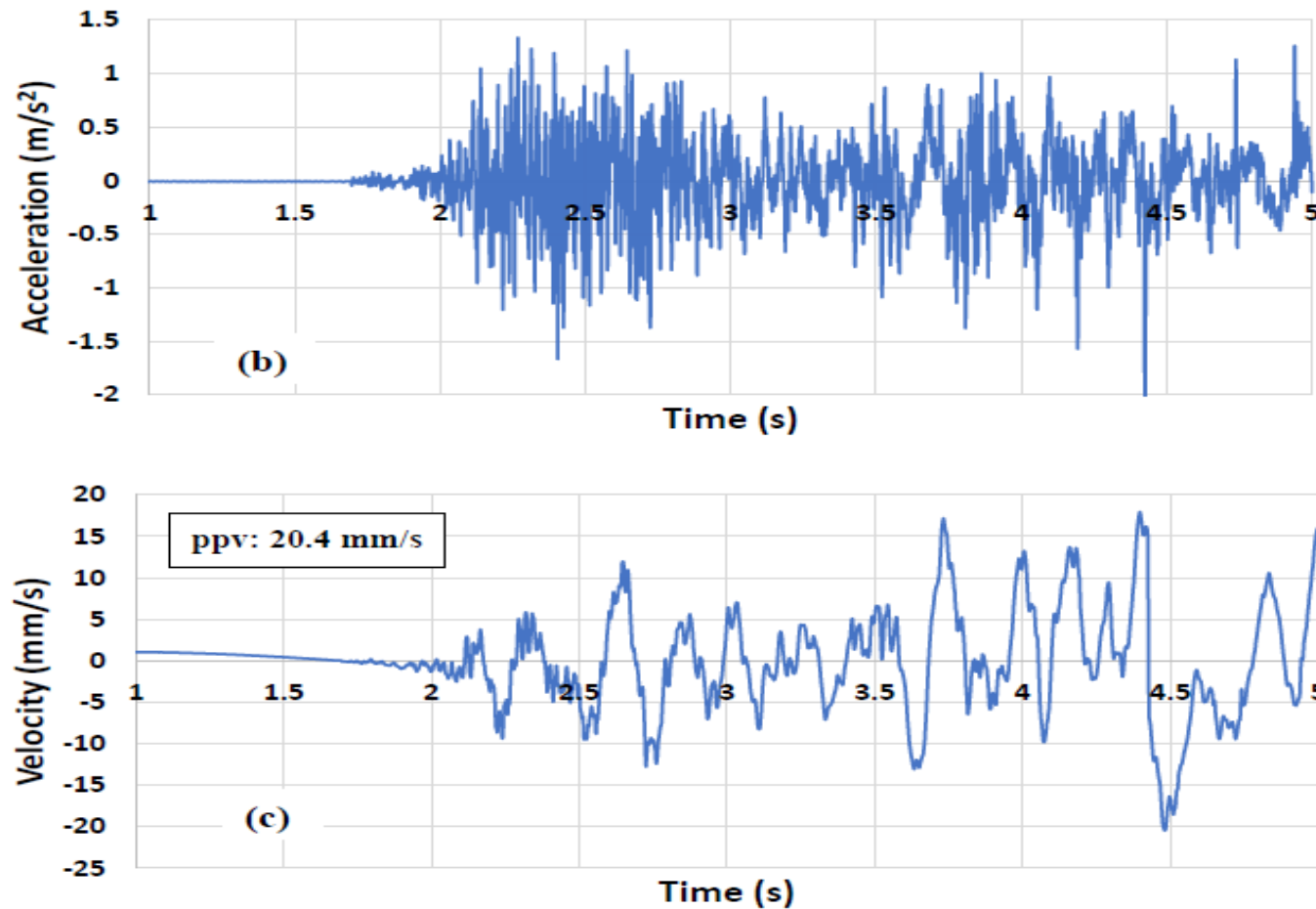


GROUND VIBRATIONS DURING DEMOLITION





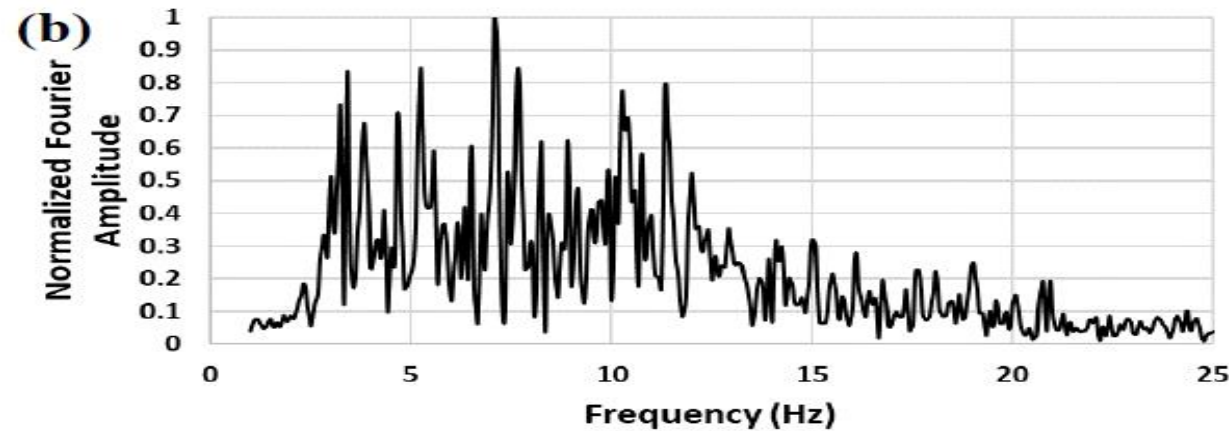
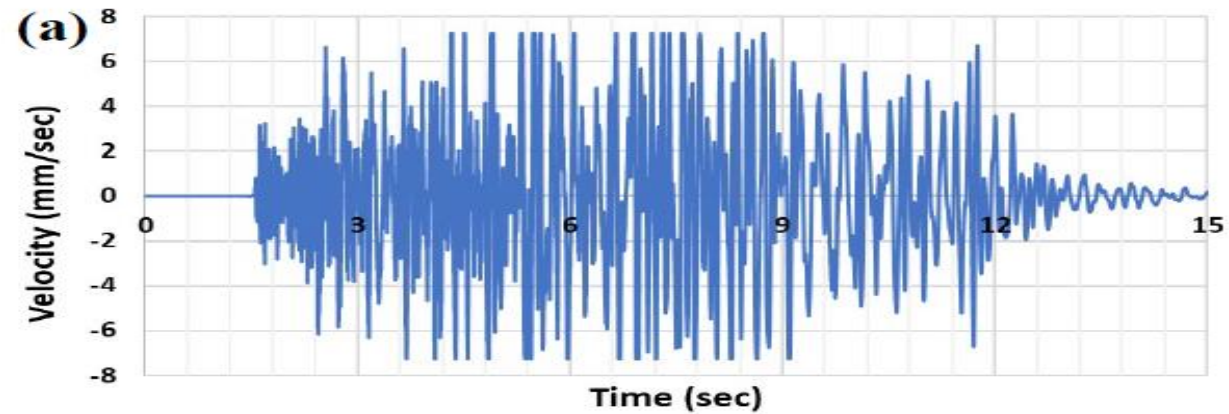
MEASURING GROUND VIBRATIONS



Filtered acceleration time history and velocity time history from the accelerometer



MEASURING GROUND VIBRATIONS



Velocity time history and frequency spectrum from geophone at Aster 2 basement



DEMOLITION DAY

SUPERTECH TWN TOWER, NOIDA

- **Demolition date: August 28, Time: 2:30 PM**
- **Demolition company: Edifice Engineering (Mumbai)**



EDIFICE
ENGINEERING
Demolition is an art, we master it
DEMOLITION (PTY) LTD
Africa's Premier Demolition Company



DEMOLITION DAY

BEFORE:



AFTER:





POST – DEMOLITION WORKS

- The structural stability of nearby buildings were ensured
- Removal of demolition wastes (building parts) being done
- Extreme caution were exercised while removing the rubble
- The remains have to be reused as much as possible
- Concrete and iron rods formed bulk of the debris
- Iron rods can be processed and used again
- Concrete parts too can be used in the construction of roads and buildings





PHOTO GALLERY





PHOTO GALLERY





PHOTO GALLERY





CONCLUSION

- Both disaster resilience and controlled demolitions prioritize structural integrity, safety, and minimal collateral damage.
- Buildings must be designed for redundancy, flexibility, and shock absorption
- Importance of risk-informed planning, early warning systems, and community preparedness
- Innovations like base isolators, dampers, and resilient materials improve survivability



CONCLUSION

- Demolition by implosion demands precision modeling, impact prediction, and blast containment.
- Tools like ETABS and blast load simulations mirror techniques used in disaster scenario modeling.
- Safety protocols for adjacent structures mirror post-disaster recovery assessments.
- Whether preparing for natural hazards or conducting planned demolitions, success depends on predictive modeling, engineering foresight, and structural resilience.
- The same principles that protect lives in disasters can guide safe dismantling of urban infrastructure.



THANK YOU