Study on Precast Prestressed Wall Panel Analyzed with Finite Element Software and Compared with Experimental Data for Economical House

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Abstract - *In recent time there is a need for the construction industry to revolve the development trade compelling it to be lot more economical in both if structural design and the construction execution. The developing approach should cover that it ought to be economical, fast and maintain the standard. For the construction concrete is the world widely used material because of its strength, handiness and affordability. The replacement of the in-situ practice of construction that is very conventional form of construction is the use of Precast concrete members in the industry because of its fast and rapid construction. For the structural designing, to avoid long mathematical calculations and performing the tests in experiment which not only consumes lot of time but also is very cost consuming since the material used for testing adds the cost, the solution can be the use of Finite element method. In this study the use of Finite element software is done to analyze the precast prestressed panel supported as a wall panel and the results are compared with technical data available. The software for this analysis is ANSYS where the model and analysis of the element is less time consuming and is very cost effective.*

Key Words: Precast concrete, finite element method, ANSYS software

1. INTRODUCTION

These days various factors are of great importance in the process of installation of structure like cost of construction, quality as well as the speed of construction. The precast concrete members the best solution for the economic advantage in construction speed in the Industry.

The connection between two panels of precast member plays the vital role in deciding the reliability and speed of construction. It is seen per the different literature that the precast concrete panel have an overall advantage over the conventional practice of construction that is in-situ construction practice. The advantages considered are its speed of construction, concrete of high strength and reliability. The reason of adopting precast technique in recent constructions is to overcome the issues concerned with the speed, cost and quality of the construction.

The features that make it different include its durability, sustainable building option, energy efficiency, property to reduce moisture and air infiltration, recyclability, low maintenance and light weight. The connection between two members are engineered so well that it acts as the monolithic behavior of the structure.

The finite element method is the effective method in determining the static nature and performance of the structure which saves time in designing and is cost effective and also increase the safety of the structure.

The long and tedious mathematical methods and experimental work were used earlier in analyzing large structures, such as high buildings, long bridges, and others. Since the accuracy involves and requires embellished techniques so most of the designer time gets involved devoted in performing mathematical analysis. The Finite element methods can be replaced and thus lets designer's free from concentrating on mathematical calculation and experimental work technique where both time is applied, cost is applied and allow them to use more time on accurate representation of the intended structure and review of the calculated performance. This is how construction time can be controlled using precast structure and to avoid long mathematical calculations and experimental testing by adopting best use of computer software can be utilized.

2. PRECAST CONCRETE

Precast concrete members are those, which are produced at factory and are transported to the site for the construction. They are very conveniently prepared at site of various shapes and can be easily erected at the site of construction.

Precast concrete members are those in which the known stresses that may occur in future is induced through the future loadings. Pre-stress is introduced by pre-tensioning RCC wires.

3. MATERIALS USED IN PRECAST CONCRETE

3.1 Concrete

The material often used due to its high structural honor and low maintenance requirements for the outside walls on commercial buildings is the concrete. The concrete unlike other building materials, develops most of its strength in the first 30 days and continues to increase it over the life of a building. The concrete proved to be a variant where the structures tends to vitiate over the period of time rather than improving. The process of hydration being the motive behind its non-traditional of advanced years, continues and complexes inside the cement gets elongate as the compounds get lengthened and interlink and create a stronger unit.

3.2 Steel

The high tension and shear strength of the steel compensate for the concrete deficiencies. The behavioral similarity in changing environments that is steel shrinks and expands with concrete helps in avoiding cracking. Steel bars made from steel with ribbing is used to bond with concrete for concrete reinforcement. The Rebar's versatility is enough in getting bent or assembled to support the shape of any concrete structure. The most common form of concrete reinforcement is Rebar made from steel with ribbing is used to bond with concrete. The steel bar with the carbon content is used as rebar material.

4. LITTERATURE REVIEW

4.1 Scanlon and Murray [1974]

This work was done on the precast concrete structures where the analysis was done using finite element software. There are two different method by which reinforced slabs can analyzed with FEM. The one is modified stiffness and the other is layer approach. This was found that precast analyzed with layer approach has better.

4.2 Mohammad Arafa and Smail [2011]

In this work was optimum cost of prestress and reinforced concrete beam is done. It was seen that as the characteristic strength was increased the optimum cost got reduced. The comparison was done with conventional concrete since increasing the characteristic strength decreased the section required which ultimately results in reduced cost.

4.3 Yasin Taha Mashal [2011]

This study was carried out at PCI that is Precast concrete institute in studying the reliability based design optimization of prestress girder. In order to maintain appropriate safety levels while performing the optimization process, it becomes necessary to adopt a probabilistic approach that considers the uncertainties associated with the basic design variables. a reliability-based optimization model, which adopts a simulation-based optimization technique is proposed for designing of prestressed concrete bridge.

5. METHODOLOGY

The research methodology used in this study is Finite element method. The research data has been collected where the similar study was carried out at MMM Gorakhpur. In this research, experimental analysis was carried out on the precast panel that was supported on the four columns. These columns was analyzed to act as the wall panel. The panel with the same data has been analyzed using the ANSYS software and results finding was compared.

5.1 Experimental data collected

The experiment data collected that was performed in year 2018 at MMM Gorakhpur by Mr. Chandan Kumar Gupta [6].

Table -1: Experimental data

Experimental data	
Size of Panel	(600x600x35) mm
Diameter of pre stressing wire	2 mm
Total number of strands used	7
Tensile strength of wire	934 MPa
Grade of concrete	M25

5.2 Elements used

The elements used in Ansys for the analysis is given below.

Table -2: Elements used

Material type	ANSYS ELEMENT
Concrete	Solid65
Tendons	Link 180
Reinforcing bar	Link 180
Material type	ANSYS ELEMENT

5.3 Finite element of concrete

The element model is the Solid 65. This is made of 8 nodes and at each node there is 3 degrees of freedom which is translations nodal x, y, and z directions.

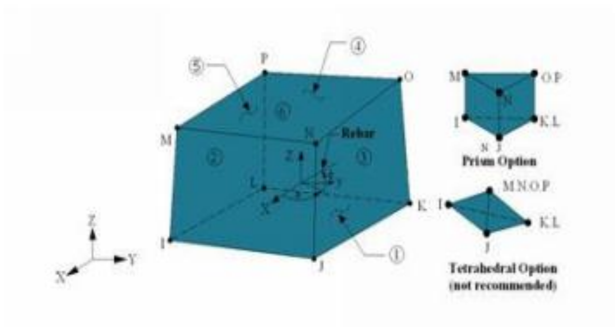

Fig -1: Concrete element Solid65 [3]

5.4 Finite element of steel and tendons

The element for tendons and reinforcement is Link180. This is also 3D element with 2 nodes and 3 degrees of freedom – translations in the nodal x, y, and z directions with the capacity of plastic deformation.

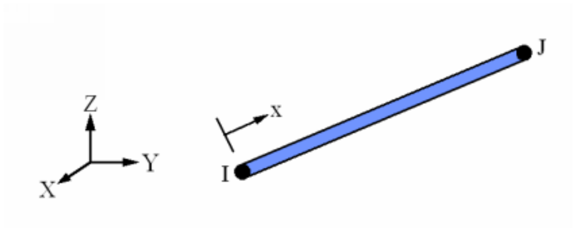

Fig -2: Tendons element Link180 [3]

6. ANALYSIS

The analysis is carried out in the slab in ten time steps. The load was increased gradually till it fails. The point load is acting at the center similar to the experimental data.

7. MODELLING

The precast prestress panel is analyzed as the wall panel that may be bearing or non-load bearing. The model prepared in ANSYS using GUI with six faces.

7.1 Description

The 600 mm x 600 mm x 35 mm slab is in accordance to the experimental data. The model is considered as the precast wall but for analysis point of view it is supported on 4 columns. The slab/wall is modelled as a volume. The elements used for concrete is Solid 65 and Link180 is used for Tendons

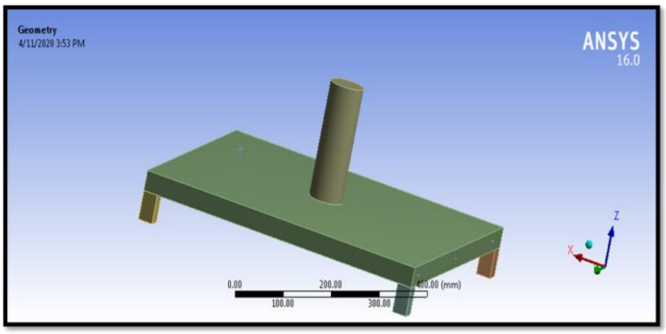

Fig -3: Software model similar to experimental

7.2 Geometry

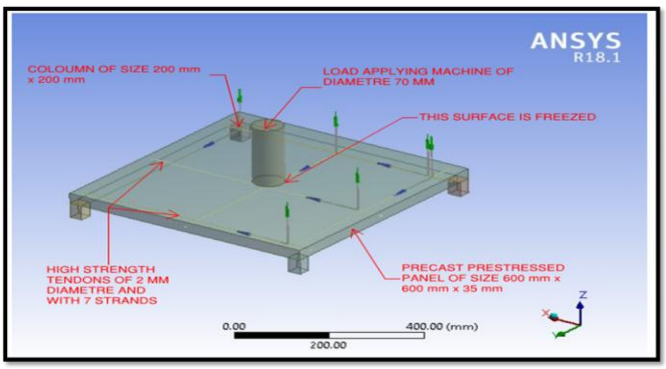

Fig -4: Geometry of the model

7.3 Material Data

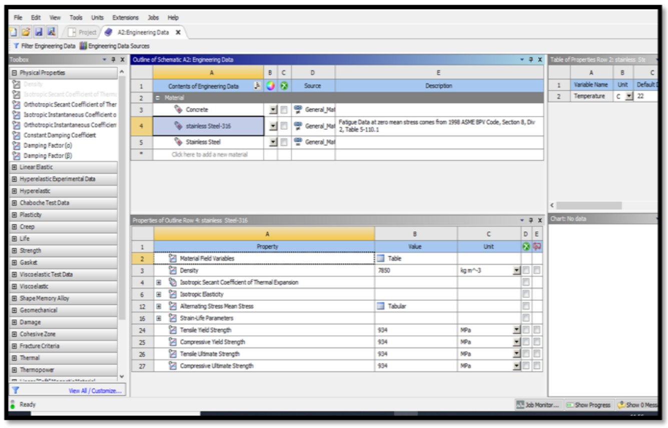

Fig -5: Material Data from software input file

7.4 Mesh Data

Extra Retries For Assembly	Yes
Rigid Body Behavior	Dimensionally Reduced
Mesh Morphing	Disabled
Statistics	
Nodes	4696
Elements	1054
Mesh Metric	None

Object Name	*Mesh*
Display Style	Body Color
Sizing	
Use Advanced Size Function	Off
Relevance Center	Coarse
Element Size	Default
Initial Size Seed	Active Assembly
Smoothing	Medium
Transition	Fast
Span Angle Center	Coarse
Minimum Edge Length	30.0 mm
Inflation	
Use Automatic Inflation	None
Inflation Option	Smooth Transition
Transition Ratio	0.272
Maximum Layers	5
Growth Rate	1.2
Inflation Algorithm	Pre
View Advanced Options	No
Number of CPUs for Parallel Part Meshing	Program Controlled
Shape Checking	Standard Mechanical
Element Midside Nodes	Program Controlled
Straight Sided Elements	No
Number of Retries	Default (4)

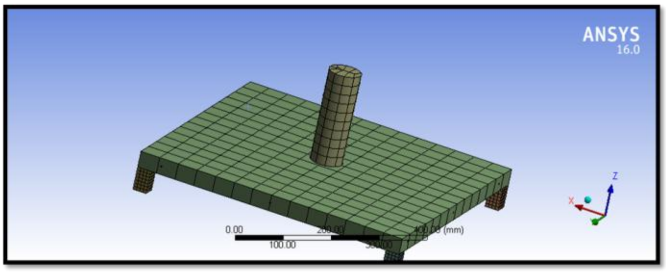

Fig -6: Arrangements of mesh of slab

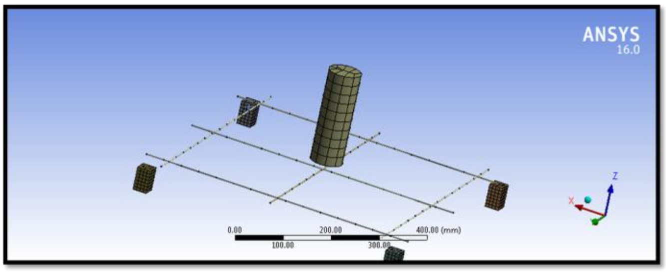

Fig -7: Arrangement of mesh of reinforcement

7.5 Boundary condition

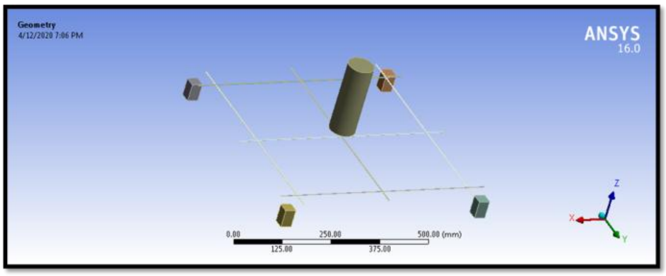

Fig -8: Boundary condition

7.6 Gravity and prestress load

Steps	Time [s]	X [N]	Y [N]	Z [N]
1	0.	0.	0.	0.
	1.			-4000.
2	2.	= 0.	= 0.	-6000.
3	3.			-8000.
4	4.			-10000
5	5.			-12000
6	6.			-14000
7	7.			-16000
8	8.			-18000
9	9.			-20000
10	10.			-22000

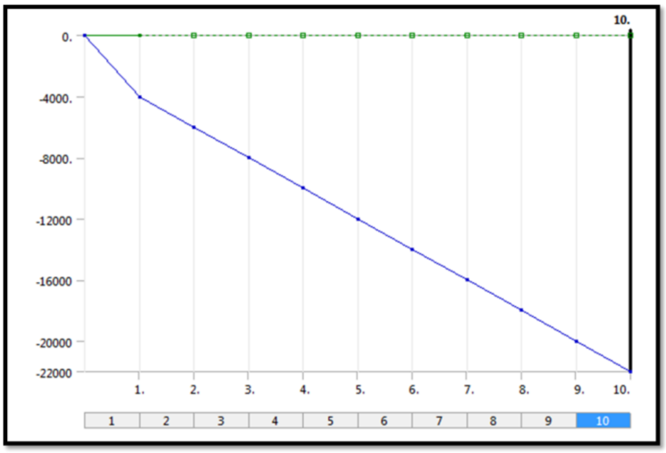

Chart -1: Gravity load

Steps	Define By	Preload [N]	Preadjustment [mm]	Increment [mm]
1.	Load	490.	N/A	N/A
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

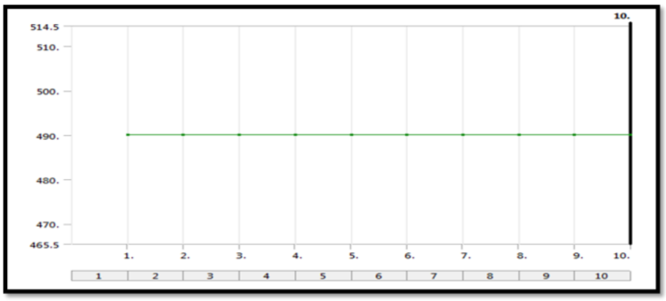

Chart -2: Pretension load

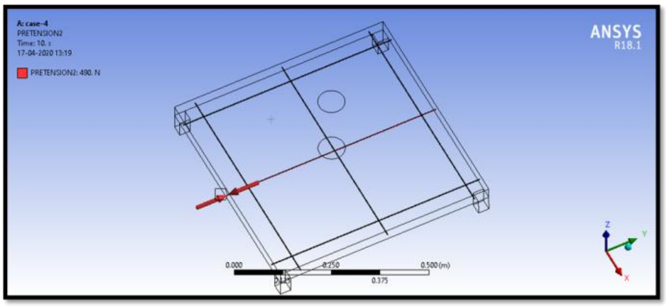

Fig -9: Load

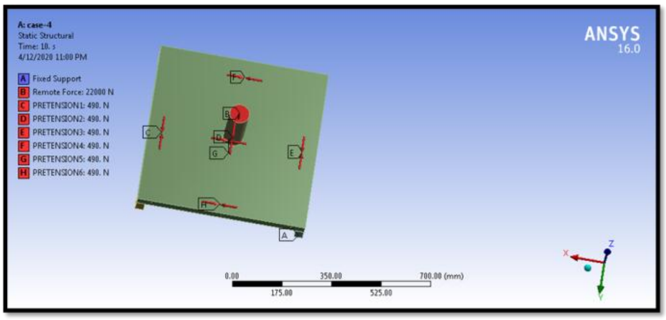

Fig -10: Gravity and pretension load simulatneously

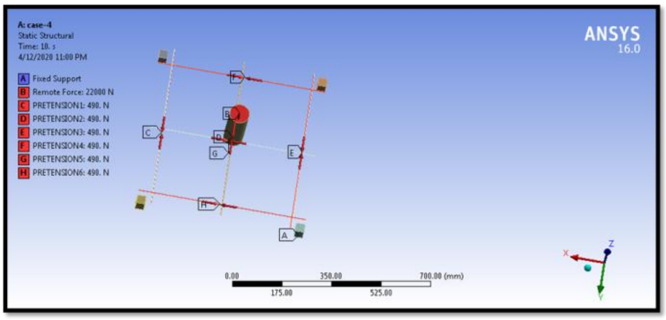

Fig -11: Load in detail view

8. RESULTS

The results for the ANSYS study are shown below.

8.1 Maximum and minimum deflection

The deflection responses towards the incremental gravity load and constant prestressing force. With every time step the deflection valued is noted at the center of the slab. The deflection is calculated at each time step that is corresponding to each load. The curve plotted at each time step gives the straight line.

Time [s]	Minimum [mm]	Maximum [mm]
1.	0.	5.3468e-003
2.		8.0181e-003
3.		1.0689e-002
4.		1.3361e-002
5.		1.6032e-002
6.		1.8703e-002
7.		2.1375e-002
8.		2.4046e-002
9.		2.6717e-002
10.		2.9389e-002

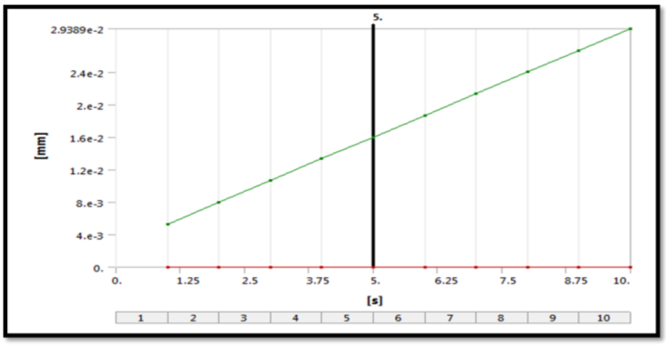

Chart -3: Deflection vs time step

8.2 Maximum and minimum stress

Time [s]	Minimum [MPa]	Maximum [MPa]
1.	2.6961e-003	1.0614
2.	3.2906e-003	1.6043
3.	3.9539e-003	2.1473
4.	4.3351e-003	2.6903
5.	4.5449e-003	3.2333
6.	4.7762e-003	3.7763
7.	5.026e-003	4.3193
8.	5.2917e-003	4.8623
9.	5.5711e-003	5.4053
10.	5.8621e-003	5.9483

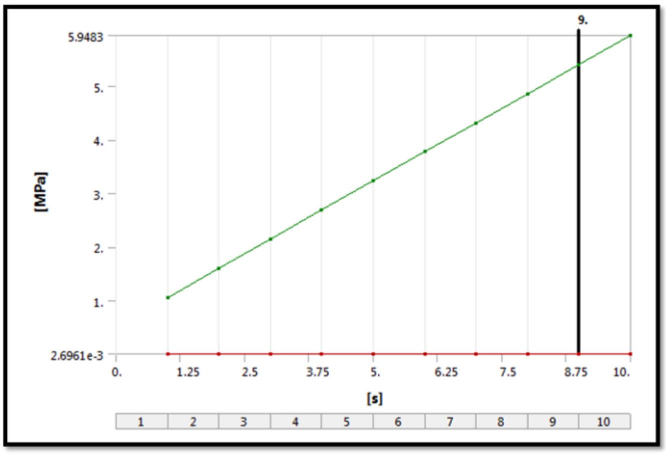

Chart -4: Stress vs time step

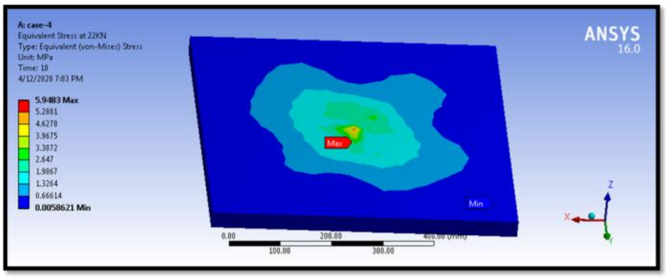

Fig -12: Equivalent stress at 22 KN

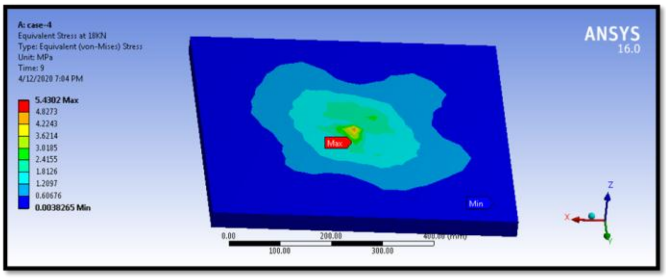

Fig -13: Equivalent stress at 18 KN

9. COMPARASION

9.1 Experimental Deflection value

The experimental results available from Mr.Chandan Kumar is shown below:

Load	Deflection at dial gauge
2.	0.00549
4	0.0078
6	0.01
8	0.0124
10	0.0158
12	0.0176
14	0.020
16	0.022
18.	0.024
20.	0.028

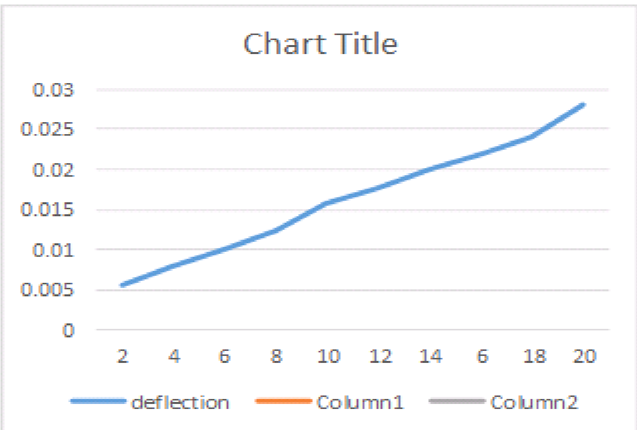

Chart -5: Experimental deflection value

9.2 Experimental and Ansys comparison

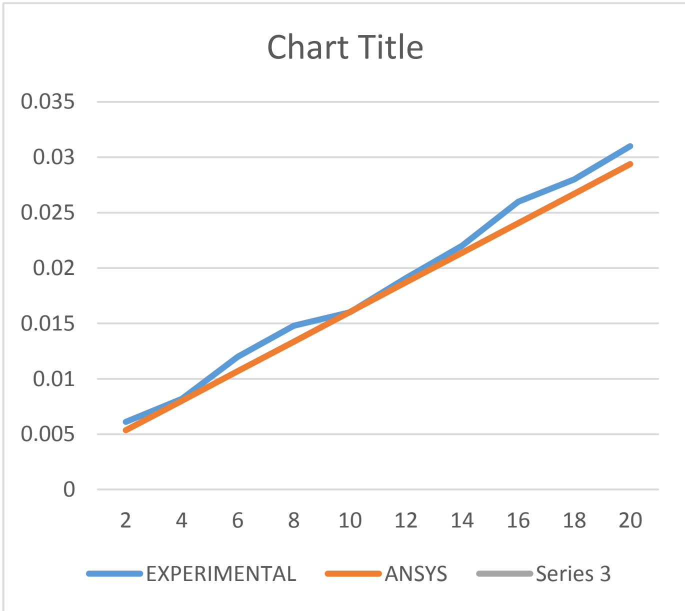

Chart -6: Comparison of experimental and ANSYS file

10. CONCLUSIONS

1. The precast prestressed slab panel was checked for the incremental increase in point load and the pattern of crack stress was recorded. This analysis is done thru FEM software ANSYS and the result was stimulated with the experimental work done by Mr. Chandan for the same panel when it will be used as the wall. It was find out that the results are in accordance and in good agreement with the experimental data and the pattern perfectly matches.

2. The model prepared in ANSYS shows the same pattern of crack and same load deflection curve so we can say that Finite element method reveals the accurate and efficient method to analyse the structural members.

3. Finite element analysis software should be used which saves time and best stimulation can be done. This saves the design time and avoid long mathematical calculations

4. This can be used against the experimental method which saves cost, time and manpower.

5. Also this can be seen that precast members are safe, easy to install.

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