STUDY ON STRENGTHING OF REINFORED CONCRETE BEAMS USING EXTERNALLY BONDED ALUMINIUM ALLOY PLATES

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ABSTRACT

The major problem in the reinforced concrete beam is no longer to be considered as safe due to various reasons such as temperature variation, chloride attacks etc., so this RC beams are either need to be replaced or strengthened. Recently developed high strength aluminium alloy have the potential to overcome some of these drawbacks by providing strengthening to the reinforced concrete beam. Compared to steel and FRP, aluminium alloy have superior properties such as ductility, good thermal and corrosion resistance. Externally bonded reinforced concrete beam with epoxy-bonded aluminium alloy plates were tested to failure using a symmetrical two point concentrated static loading system. A beam with 2 layers and 3 layers of aluminium alloy plates are externally bonded with the use of epoxy resin and the conventional beam is casted and tested under two point loading system, and analyzed by the ANSYS Software. The results clearly show that, the 3 layers of externally bonded aluminium alloy plates significantly increases the strength than the conventional beam

Keyword: - *Aluminium alloy plates, two point loading, epoxy resins, etc….*

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1. INTRODUCTION

There are various RC structures started getting deteriorated over yearsdue to various environmental factors including carbonation, chloride attack,corrosion, etc. According to new design code book, moreover a large number of structures constructed in the past using the older design codes in different parts of the world are structurally unsafe. These structures need to be either replaced or strengthened with external support using innovative methods. Since replacement of such deficient elements of structures incurs a huge amount of public money and time strengthening has became the more acceptable way of improving the loadcarrying capacity and extending the service lives. The existing methods are usingsteel plates or fiber reinforced polymer (FRP) plates or sheets. But there are various disadvantages in the above methods. So, researchers have been trying to get an alternative for the above methods.

Aluminium alloy plates are very good alternative comparing steel and FRP because of the isotropic, highly ductile, good thermal and corrosion resistance, and high strength to weight ratio properties. However, proper execution is required. Externally bonded reinforced concrete beam with epoxy-bonded aluminium alloy plates were tested to be failure using a symmetrical two point concentrated static loading system. A beam with 3 layers of externally bonded aluminium alloy plates gives better strengthening compared to a beam with 2 layers and conventional beam. In this study the 3 layer beam is tested with two point loading system and analyzed with ANSYS software.

1.1 STRENGTHENING OF MATERIALS

An aluminium alloy 5052 is used here to strengthen the RC Beam. This type of aluminium alloy is mostly used in marine and chemical industries to controlcorrosion.

1.1.1 USING ALUMINIUM ALLOY

An aluminum alloy is a chemical composition where other elements are added to pure aluminum in order to enhance its properties, primarily to increase its strength. These other elements include iron, silicon, copper, magnesium, manganese and zinc at levels that combined may make up as much as 15 percent of the alloy by weight. Alloying requires the thorough mixing of aluminum with these other elements while the aluminum is in molten – liquid – form. The addition of elements to the aluminum gives the alloy improved strength, workability,corrosion resistance, electrical conductivity, and density, compared with the pure metallic element. Aluminum alloys tend to be lightweight and corrosion resistant.

1.1.2 TYPES OF ALUMINIUM ALLOY

There are different types of aluminium alloys that belong to eight different series

1000 series

Commercially pure aluminum also has a four-digit numerical identifier. Series 1000 alloys are made of 99 percent or higher purity aluminum.

2000 series

The principal alloying element in the 2000 series is copper. Heat treating these alloys improves their strength. These alloys are strong and tough, but not as corrosion resistant as other aluminum alloys, so they are usually painted or coatedfor use.

3000 series

The main alloying element in this series is manganese, usually with a smaller amount of magnesium. The most popular alloy from this series is 3003, which is workable and moderately strong.

4000 series

Silicon is added to aluminum to make 4000 series of alloys. This lowers the melting point of the metal without making it brittle. This series is used to make welding wire. Alloy 4043 series of alloy is used to make filler alloys for weldingcars and structural elements.

5000 series

The principal alloying element in the 5000 series is magnesium. These alloys are strong, weldable, and resist marine corrosion. The 5000 series alloys are used tomake pressure vessels and storage tanks and for various marine applications

6000 series

Silicon and magnesium are present in 6000 series of alloys. The elements combineto form magnesium silicide. These alloys are formable, weldable, and heat treatable. They have good corrosion resistance and moderate strength.

7000 series

Zinc is the principal alloying element in the series starting with the number. The resulting alloy is heat-treatable and very strong. Important alloys are 7050and 7075, both used to construct aircraft.

8000 series

These are aluminum alloys made with other elements. Examples include 8500, 8510, and 8520.

1.1.3 ADVANTAGE OF ALLUMINIUM ALLOY

- Light weight
- Excellent Corrosion Resistance
- Strong at Low Temperatures
- Easy to Work
- Easy Surface Treatment

1.1.4 APPLICATION

The structural applications in the field of civil engineering as follow

- Long-span roof systems in which live loads are small compared with dead loads, as in the case of reticular spacestructures and geodetic domes covering large span areas, like halls and auditoriums.
- Long-span roof systems in which live loads are small compared with dead loads, as in the case of reticular spacestructures and geodetic domes covering large span areas, like halls and auditoriums.
- Structures situated in corrosive or humid environments such as swimming pool roofs, river bridges, hydraulic structures andoffshore super-structures.
- Structures having moving parts, such as sewage plant cranebridges and moving bridges, where lightness means economyof power under service.
- Structures for special purposes, for which maintanence operations are particularly difficult and must be limited, as in case of masts, lighting towers, antennas towers, sign motorway portals and so on.

1.2 OBJECTIVE OF THE STUDY

- To study the flexural behaviour of reinforced concrete beams strengthened with aluminium alloy plates in different layers
- To study the effect of using aluminium alloy plates in layer
- To investigate the deflection, crack patterns and modes offailure
- To propose analytical model using FEM software and summarize the result

1.3 SCOPE OF THE STUDY

- Aluminium is economical and abundant so it can be used in constructions in future compared to any other metals
- This study will gives some knowledge about the using of aluminium alloy plates in order to increase the strength of the concrete
- The effect of using externally bonded aluminium alloy plates in reinforced concrete beam can be examined
- This study gives details about its structural behaviour such as strength, deformation, and analysis of beam which provide safeand durable structure.

1.4 PRESENT INVESTIGATION

The purpose of this research is to study the Flexural behaviour of the externally bonded aluminium alloy plates with the various layers in the beam. The strength of this orientation is studied. ANSYS modelling is done for the analysis of the member. The RC beam is strengthened with the AA plates. In which 3 layers of AA plates are assembled with this member. The various characteristics of the member are studied.

2. SOFTWARE ANALYSIS

2.1 GENERAL

The ANSYS Workbench environment is an intuitive up-front finite element analysis tool that is used in conjunction with CAD systems and/or Design Modeller. ANSYS Workbench is a software environment for performing structural, thermal, and electromagnetic analyses. The class focuses on geometry creation and optimization, attaching existing geometry, setting up the finite element model, solving, and reviewing results. The class will describe how to use the code as well as basic finite element simulation concepts and results interpretation.

ANSYS is a general purpose software, used to simulate interactions of all disciplines of physics, structural, vibration, fluid dynamics, heat transfer and electromagnetic for engineers.

ANSYS can import CAD data and also enables to build a geometry with its "pre-processing" abilities. Similarly in the same pre-processor, finite element model (a.k.a. mesh) which is required for computation is generated. After defining loadings and carrying out analyses, results can be viewed as numericaland graphical. ANSYS can carry out advanced engineering analyses quickly, safely and practically by its variety of contact algorithms, time based loading features and nonlinear material models.

ANSYS Workbench is a platform which integrates simulationtechnologies and parametric CAD systems with unique automation andperformance. The power of ANSYS Workbench comes from ANSYS solver algorithms with years of experience. Furthermore, the object of ANSYS Workbench is verification and improving of the product in virtual environment.

2.1.1 ANSYS MODELLING

The analysis focuses on

- Engineering data
- Geometry creation and optimization,
- Attaching existing geometry,
- Setting up the finite element model,
- Solving and
- Results.

2.1.2 FEM MODELLING

2.1.3 ENGINEERING DATA

Material properties have to be included like grade of steel, grade of concrete, admixtures etc. there I have changed the properties of the material as per my specifications. The material properties which taken are tabulated below in table 1.1

Table 1.1 Properties of Concrete, Epoxy, Aluminium alloy, Steel

PROPERTIES	CONCRETE	EPOXY	ALUMINIUM ALLOY	STEEL
Density	2400 kg/m^3	1.1 g/cm^3	2.68 g/cm^3	7850 kg/m^3
Modulus of Elasticity (Ec)	31.3 GPa	4.5 GPa	70 GPa	200 GPa
Reference temperature	200^0C	200^0C	200^0C	200^0C
Poisson's ratio(μ)	0.2	0.34	0.33	0.3
Ultimate strength	38.5 Mpa	54 Mpa	200 Mpa	2 Mpa

2.2.1 MODELLING

The model is created in the space claim which is the part of the ANSYS WORKBENCH. Here, the members are assembled, the properties of eachcomponent is given. The beam with size of 1000 x 150mm was created with reinforcement of 12mm diameter in longitudinal and transverse direction with aluminium alloy plates at the bottom in 2 & 3 layers which is bond with epoxy. Themodels are shown in the below figure 1.1 to 1.3.

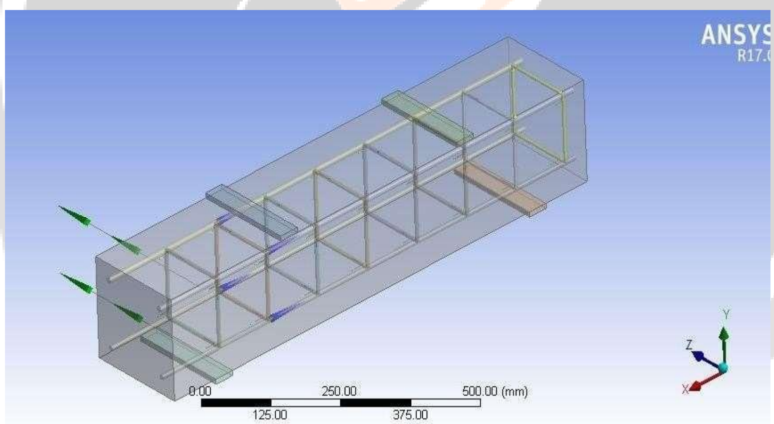

Fig 1.1 RC Conventional Beam

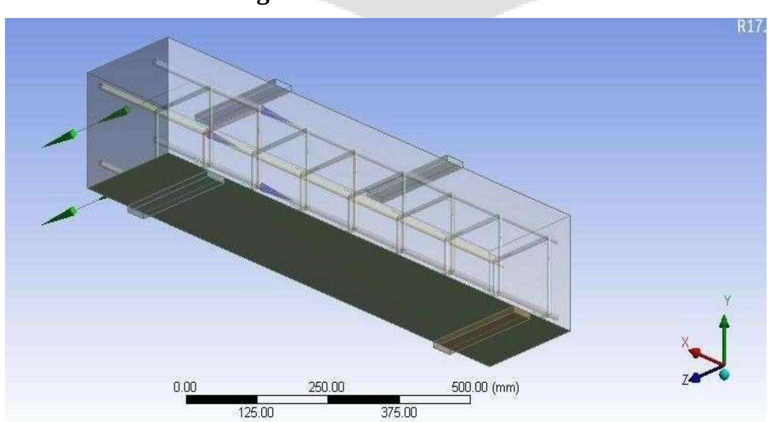

Fig 1.2 Beam with Two Layer of Aluminium Alloy

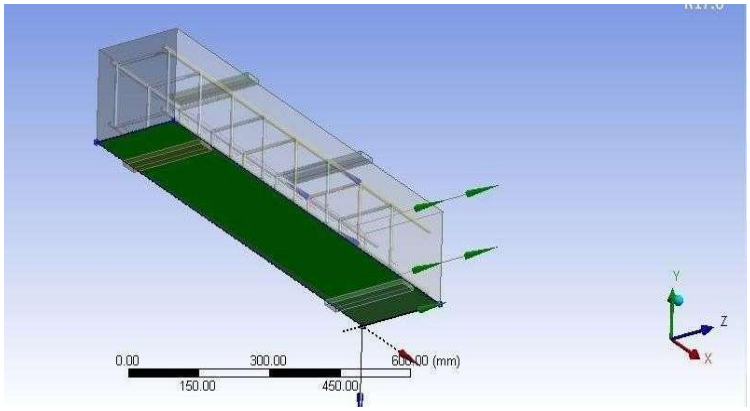

Fig 1.3 Beam with Three Layer of Aluminium Alloy

2.2.2 MESH CREATION

Meshing is an integral part of the engineering simulation process where complex geometries are divided into simple elements that can be used as discrete local approximations of the larger domain. The mesh influences the accuracy, convergence, and speed of the simulation. The mesh for RC beam and beam with aluminium alloys are shown below in the figure 1.4 to 1.6.

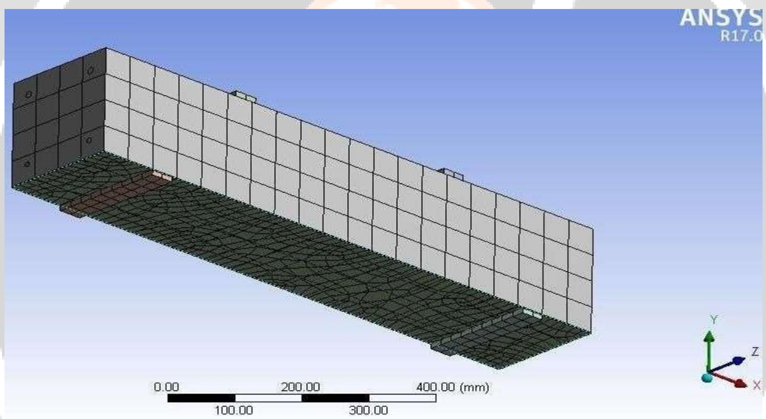

Fig 1.4 Meshing of RC Conventional Beam

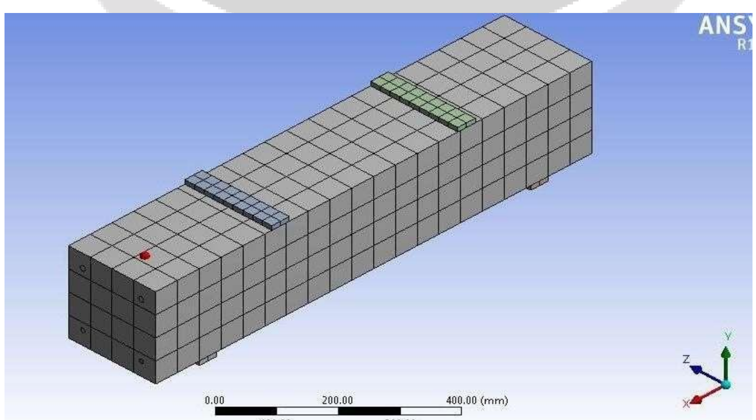

Fig 1.5 Meshing of Beam with Two Layer of Aluminium Alloy

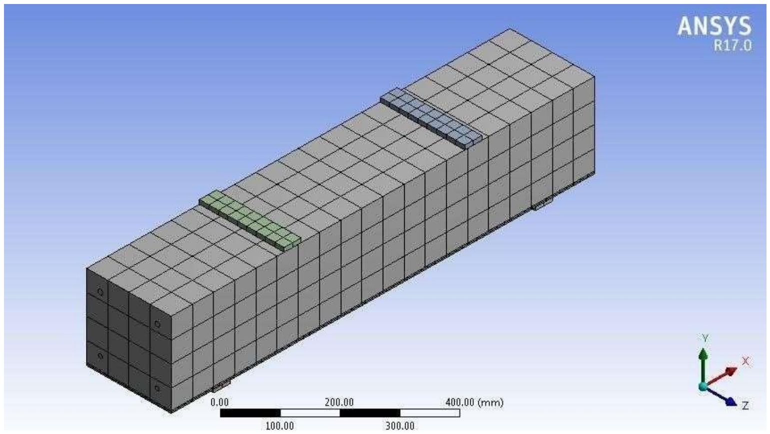

Fig 1.6 Meshing of Beam with Three Layer of Aluminium Alloy

2.2.6LOAD APPLICATION

The load is applied as two point loading in a static manner which isrepresented in figure 1.7

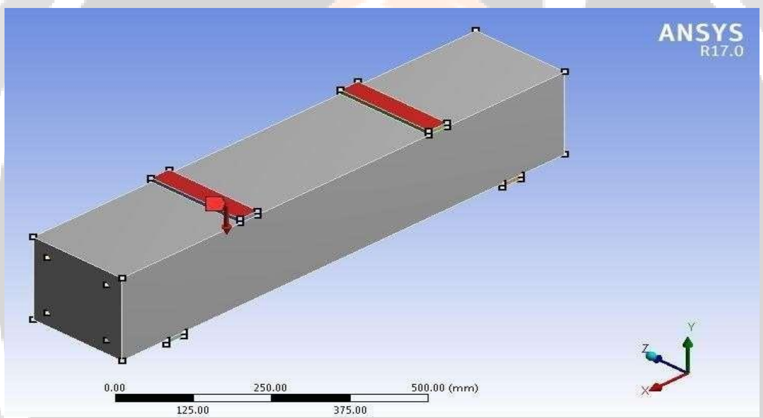

Fig 1.7 Load Application

2.2.7 ANALYSIS OF MODEL

After the application of load and support condition to the model, it willbeready for the analysis. Now we can run the analysis and get the results.

2.2.8 RESULTS OF MODEL

The results which are obtained from the analysis using ANSYSsoftwareare shown below.

- **Deformation**

Total deformation and Directional deformation for both RC beam andbeam with aluminium alloy plates are shown below from figure 1.8 to 1.10.

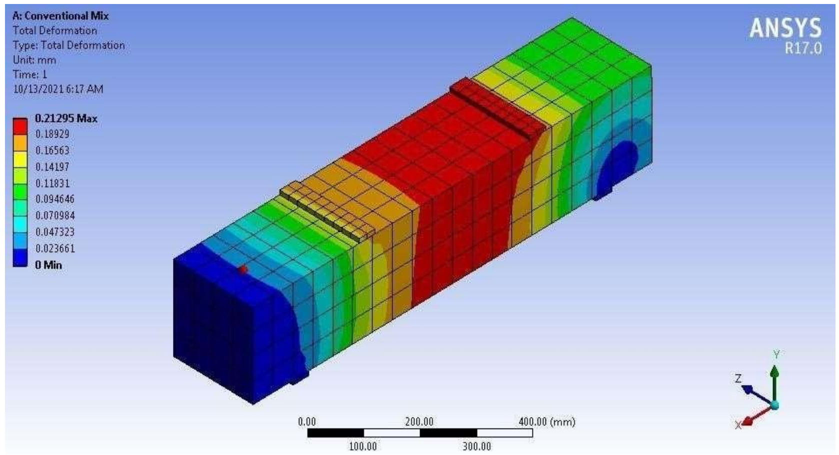

Fig 1.8 Total Deformation in RC Conventional Beam

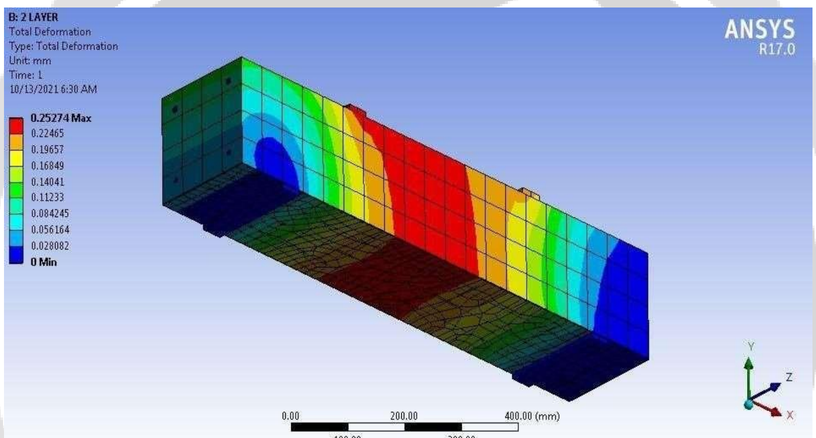

Fig 1.9 Total Deformation in Beam with Two Layer of Aluminium Alloy

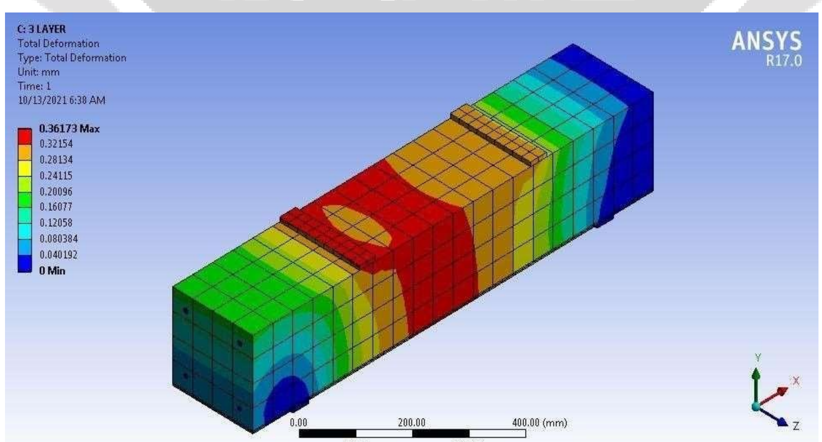

Fig 1.10 Total Deformation in Beam with Three Layer of Aluminium Alloy

3.1 DISCUSSION OF RESULTS

The obtained results were discussed below.

3.1.1 DEFLECTION BEHAVIOUR

3.1.1.1 The presence of aluminium alloy plate in 3 layers on thebeam significantly reduces the deflection.

3.1.1.2 At the ultimate load, when compared to the aluminium alloyplated beam the deflection is less.

4.1 EXPERIMENTAL WORK

4.1.1 GENERAL

In this chapter, the details of materials and properties of each material in tested and studied as per IS codes and the experimental work procedure for specimen were given.

4.1.2 PRELIMINARY TESTS

The aim of the preliminary test is to demonstrate, through test carriedout on concrete manufactured in laboratories that using the planned materials, dosage,and construction methods it is possible to obtain concrete that present the strengthand durability condition by the design.

4.1.3 CEMENT

4.1.3.1 Cement is a binder, a substance used for construction that sets, hardens, and adheres to other material to bind them together.

4.1.3.2 Different types of cement have been found to possess different strength development characteristics and rheological behaviour due to the variations in the compound composition and fineness.

4.1.3.3 In this experimental study, Ordinary Portland Cement conforming to IS: 8112-1989 was used. The physical and chemical properties of the cement used are shown in table 1.2 and figure 5.1

Table 1.2 Specific Gravity of Cement

TEST	RESULTS
Specific Gravity	3.1

5.1.1 FINE AGGREGATES

- Now a day river sand is not available economically, however crushed stone aggregate can replace 100% river sand in a concrete mix proportion.
- The sand used for experimental program was locally procured andconforming to zone II.
- IS 2326 part3 1963 – Specific gravity. The physical and chemical properties of the fine aggregate used are shown in table 5.2

Table 1.3 Specific Gravity of Fine Aggregate

S NO	DESCRIPTION	TRIAL I (kg)	TRAIL II (kg)	TRAIL III (kg)
1.	Weight of emptypycnometer (w1)	0.497	0.497	0.497
2.	Weight of pycnometer + Fine aggregate (w2)	1.113	1.114	1.114
3.	Weight of pycnometer+Fine Aggregate+ Water(W3)	1.894	1.895	1.895
4	Weight of Water(W4)	1.514	1.514	1.514
5.	Specific Gravity = $\frac{(W2-W1)}{(W4-W1)-(W3-W2)}$	2.61	**2.61**	**2.61**
			Specific Gravity=2.61	

5.1.2 COARSE AGGREGATES

- Aggregate is also a very important for strength, thermal and elastic properties of concrete.
- Maximum coarse aggregate size used is 20 mm and the minimum coarse aggregate size used is 10 mm.
- IS 2326 part3 1963 – Specific gravity. The physical and chemicalproperties of the coarse aggregate used are shown in table 5.3 and figure 5.3

Table 1.4 Specific Gravity of Coarse Aggregate

S NO	DESCRIPTION	TRIAL I (kg)	TRAIL II (kg)	TRAIL III (kg)
1.	Weight of empty pycnometer (w1)	0.497	0.497	0.497
2.	Weight of pycnometer +coarse aggregate (w2)	1.170	1.170	1.170
3.	Weight of pycnometer+ Coarse Aggregate + Water(W3)	1.800	1.800	1.800
4.	Weight of Water(W4)	1.508	1.508	1.508
5.	Specific Gravity = $\frac{(W2-W1)}{(W4-W1)-(W3-W2)}$	2.71	2.71	2.71
			Specific Gravity=2.71	

5.1.3 SIEVE ANALYSIS (FINE AGGREGATE)

Sieve analysis of fine aggregates is one of the most important tests performed on-site. Aggregates are inert materials that are mixed with binding materials such as cement or lime for the manufacturing of mortar or concrete. All Aggregates pass IS 4.75 mm sieve is classified as fine aggregates. The physical and chemical properties of the fine aggregate used are shown in table 5.4

Table 1.5 Sieve Analysis (Fine Aggregate)

SIEVE SIZE	TRIALI (kg)	TRIAL II (kg)	TRIAL III (kg)	AVERAGE (g)	% RETAINED	CUM% RETAINED	% PASSING
4.75 mm	0	0.003	0.004	2.3	0.23	0.23	99.7
2.36 mm	0.018	0.016	0.017	17	1.7	1.93	98.07
1.18 mm	0.388	0.426	0.423	412.33	41.233	43.163	56.837
600 µm	0.254	0.160	0.165	159.66	15.966	59.129	40.871
300 µm	0.231	0.223	0.195	216.33	21.633	80.762	19.238
150 µm	0.174	0.141	0.167	160.66	16.066	96.528	3.172
Pan	0.041	0.036	0.042	39.66	3.96	100	0

5.1.4 SIEVE ANALYSIS (COARSE AGGREGATE)

Sieve analysis helps to determine the particle size distribution of the coarse aggregates. This is done by sieving the aggregates as per IS: 2386 (Part I) – 1963. In this we use different sieves as standardized by the IS code and then pass aggregates through them and thus collect different sized particles left over different sieves. The physical and chemical properties of the coarse aggregate used are shown in table 5.5

Table 1.6 Sieve Analysis (Coarse Aggregate)

SIEVE SIZE (mm)	TRIALI (kg)	TRIAL II (kg)	TRIAL III (kg)	AVERAGE (g)	% RETAINED	CUM% RETAINED	% PASSING
20	0.335	0.322	0.266	307	10.23	10.23	89.77
13.2	2.252	2.434	2.464	2380	79.3	89.3	10.7
12.5	0.063	0.033	0.024	40	1.3	90.6	9.4
10	0.248	0.154	0.159	187	6.23	96.83	3.17

Pan	0.097	0.066	0.065	76	2.53	100	0

5.1.5 WATER

Water is the essential one in the construction work. It is used for the preparation of cement mortar, mixing of cement concrete and curing work etc. According to the usage of quality of water the strength of the cement concrete andthe cement mortar value may changes. The water which is used for curing and mixing purpose which should be free from alkali, salt, acid etc.. Usage of impuritiesof water can cause corrosion, shrinkage and even reduces the strength of the concrete.

5.2 COMPRESSIVE STRENGTH TEST

The **Compressive strength test** helps us to know the overall strengthand the above factors. By conducting this test, one can easily determine the strength psi of the concrete and the quality of the concrete being produced. The **Concrete Cube Test** will give compressive strength of concrete which gives anidea of all the properties of concrete. By this unique test, we can decide whetherthe concretingwas done correctly or not. The compressive strength of concrete ranges from 15MPa (2200 psi) to 30 MPa (4400 psi) for residential concrete and is high in commercial structures. Some applications use forces greater than 10,000 psi (70 MPa). The below table 1.7 shows the result of first crack load, ultimate load and compressive strength.

Table 1.7 Compressive Strength

CUBE M 30	**COMPRESSIVE STRENGTH (7 days) (N/mm^2)**	**COMPRESSIVE STRENGTH (28 days) (N/mm^2)**
C1	17.5	28.4
C2	18.3	29.3
C3	17.9	29

Fig 5.4 Compressive Strength Test

5.3 SPECIFICATIONS

5.3.1 BEAM PARAMETER

- *Dimensions of the Beam*

Length = 1000 mm Width = 100 mm Overall depth = 150 mmM30 grade of concrete Fe 550 grade of steel

- *Reinforcements*

12 mm diameter rod @ 80 mm c-c.8mm diameter @ 170mm c-c.

5.3.2 ALUMINIUM ALLOY PARAMETER

Width = 100 mm Length = 1000 mm Thickness = 1 mm

5.3.3 SPECIMEN DETAILS

The specimen details are shown in the below table 5.7

Table 1.8 Specimen Details

S.NO	SPECIMEN DESIGNATION	DIMENSION (mm)	ALUMINIUM ALLOY LAYERS
1.	CB	1000X150X100	NIL
2.	A2S	1000X150X100	2
3.	A3S	1000X150X100	3

- CB = RC Conventional Beam
- A2S = Beam with 2 layer of Aluminium alloy at bottom
- A3S = Beam with 3 layer Aluminium alloy at bottom

5.4 MIX RATIO

- M40 Grade of concrete
  - OPC 53 grade cement
  - Cement = 425 kg/m^3
  - Fine Aggregates = 588 kg/m^3
  - Coarse Aggregates = 1208 kg/m^3
  - Water-Cement ratio: 0.45
- The mix ratio is shown in the below table 1.9

Table 1.9 Mix ratio

Cement	Fine Aggregates	Coarse Aggregates
1	1.38	2.8

5.5 CASTING OF SPECIMEN

- The beam was filled with M30 concrete grade mix proportion and itencloses with reinforcement of 12mm and 8 mm diameter.
- The casting image is shown in figure 5.5.
- The application of aluminium alloy layer is shown in figure 5.6, 5.7

Fig 5.5 Casting of Beam Specimen

Fig 5.6 Applying Epoxy in Aluminium Alloy Plate

Fig 5.7 Fixing the Plates in Layer

5.6 CURING OF SPECIMEN

Curing of specimen is given below. The compressive strength of thespecimenwill be taken after 7, 14 and 28 days.

- Number of cubes = 7
- Number of beams = 6
- Cube size = 150x150x150 mm^3
- beam size =1000x150x100mm^3

5.7 EXPERIMENTAL SETUP

The beams were tested in the loading frame of the “Structural Engineering” Laboratory of JAYA ENGINEERING COLLEGE. The testing procedure for all the specimen is same. First the beams are cured for a period of 28 days then its surface is cleaned with the help of sand paper for clear visibility of cracks. The RC conventional beam and strengthened beams with externally bonded with aluminium alloy plates were tested under two point loading using loadingframe. The control beams was used as a benchmark for comparison with the strengthened beams. The load is transmitted through a load cell are used to measure the applied load on the tested specimen. The mid span deflection was measured at each load steps by using linear variable displacement transducer. By using this in order to find out the maximum load and deflection of the beam. Two point loading arrangement is done as shown in the fig 5.8

Fig 5.8 Experimental Setup

5.8 TESTING OF SPECIMEN

All the specimens were tested one by one another. There are totally 3 variations are tested. Conventional beam and beam with 3 and 2 layers of aluminium alloy plates at bottom. The gradual increase in load and the deformation in the strain gauge reading are taken throughout the test. The dial gauge reading shows the deformation. The load at which the first visible crack is developed is recorded as cracking load. The specimen kept on the loading frame were shown in figure 5.9. Thetested specimens were represented in figure 5.10 to 5.12.

Fig 5.9. Loading Frame with Specimen

Fig 5.10 RC Conventional Beam

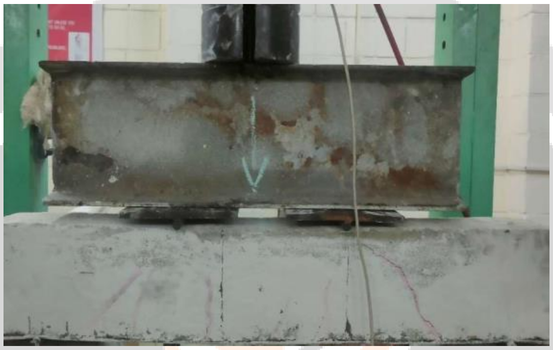

Fig 5.11 Beam with Two Layer of Aluminium Alloy Plates at Bottom

Fig 5.12 Beam with Three Layer of Aluminium Alloy Plates at Bottom

6. RESULTS AND DISCUSSION

6.1 LOAD - DEFLECTION CHARACTERISTICS

The results between experimental results with analytical results were compared. The below table 6.1 shows that results of beam with maximum load and deflection.

Table 6.1 Results Comparison

SPECIMEN DESIGNATION	ANALYTICAL RESULTS		EXPERIMENTALRESULTS	
	LOAD (kN)	DEFLECTION (mm)	LOAD (kN)	DEFLECTION (mm)
CB	122	5.21	120	5.35
A2S	155	5.28	150	5.55
A3S	190	6.4	183	6.89

Here the comparison shows, the load carrying capacity of A3S is higher compared with other beams. It increases up to 22% with A2S and 52% with CB. In the case of 3 layers of aluminium alloy plates at bottom shows more strength compared with other beams. The ultimate load of the A3S and A2S are 183kN and 150kN respectively and the maximum deflection are 6.89 mm and 5.55 mm. The comparison of load-deflection curve were plotted and represented in figure 6.1 to 6.4

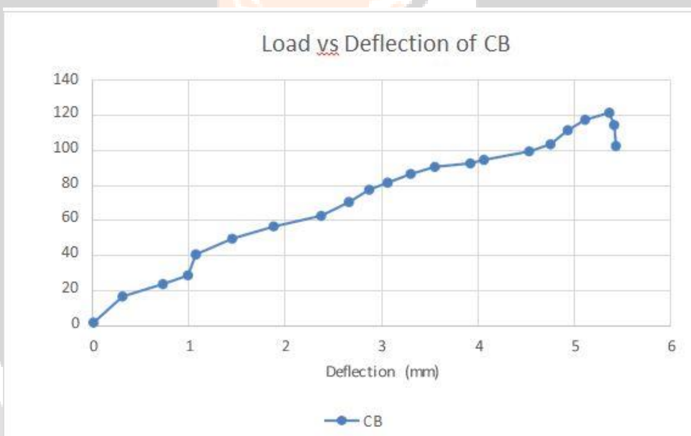

Fig 6.1 Experimental Result of Load vs Deflection Curve for RC Conventional Beam

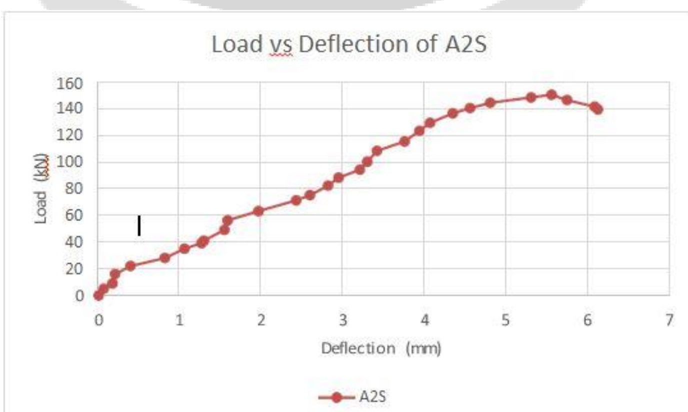

Fig 6.2 Experimental Result of Load Vs Deflection Curve for RC Beam with two Layer of Aluminium Alloy

Fig 6.3 Experimental Result of Load Vs Deflection Curve for RC Beam withThree Layer of Aluminium Alloy

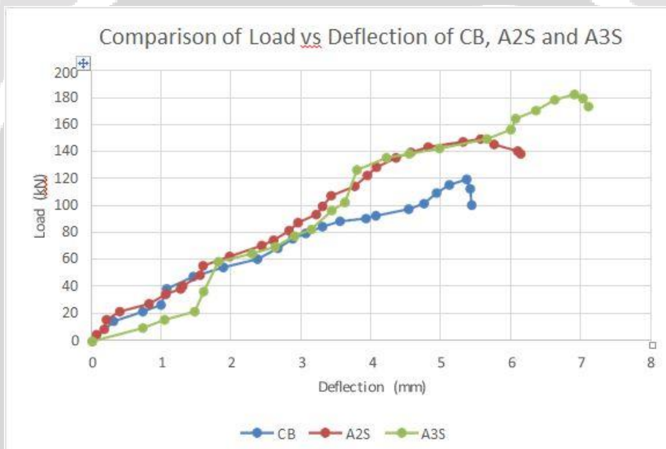

Fig 6.4 Comparison of Experimental Result of Load Vs Deflection Curve forRC Conventional Beam and Beam with Two and Three Layer of AluminiumAlloy

6.2 FLEXURAL STRENGTH TEST

All the beam specimens were tested under simply supported end conditions. Two points loading is adopted for testing. The reason for adopting two points loading is to test the beams in flexure. The beam specimen of dimension is 1000x150x100mm.The flexural strength is calculated in the below table 6.2

Table 6.2 Flexural Strength

SPECIMEN DESIGNATION	FLEXURAL STRENGTH (Mpa)	
	ANALYTICAL RESULTS	EXPERIMENTAL RESULTS
CB	54.22	53.33
A2S	68.86	66.66
A3S	84.4	81.33

The flexural strength for beam with 3 layers of aluminium alloy plates at bottom shows 52% increase in load compared with the CB beam. Then, the beam with 2 layers of aluminium alloy shows 24% increase in load when compared with the CB. In analytical result the flexural strength for beam with 3 layers of 3 layers of aluminiumalloy plates at bottom shows 55% increase in load compared with the CB beam. Then, the beam with 2 layers of aluminium alloy shows 25% increase in load when comparedwiththeCB.

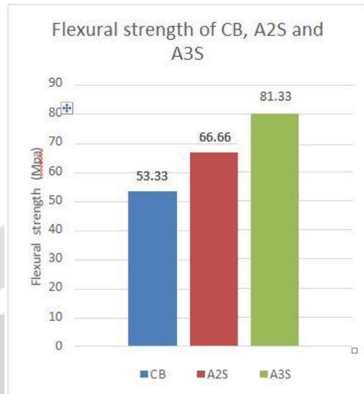

Fig 6.5 Comparison of Flexural Strength of RC Conventional Beam andBeam with Two and Three LayerofAluminiumAlloy

6.3 DUCTILITY

Ductility of the member is defined as the ability of the member to sustain the deformation. The ductility index was calculated and the results were shown in table 6.3. The ductility increases in 3layers of aluminium alloy plates.

TABLE 6.3 RESULTS BASED ON DUCTILITY

SPECIMEN DESIGNATION	FIRST CRACK		DUCTILITY INDEX
	LOAD (kN)	DEFLECTION (mm)	
CB	100	4.63	1.15
A2S	140	4.55	1.21
A3S	155	5.21	1.32

7.CONCLUSION

In this study, Analytical and Experimental work have been carried out to simulate the structural behaviour of beam under two points bending. Literatures were studied properly and some of the required data have been taken from theliterature survey. The flexural behaviour of RC beam strengthened with externally bonded aluminium alloy plates with different layers such as two layers and three layers was investigated. Analytical study was done using the ANSYS Software. The load-deflection characteristics graphs were plotted. The summarized conclusions based on this study are given below.

- It is observed that the load carrying capacity is vary with aluminiumalloy plates when compared with RC conventional beam thus it can be concluded that the layers of aluminium alloy plates at bottom hasa greater influence on external strengthening.
- Based on the result investigation the load carrying capacity of 3 layer of aluminium alloy is higher compared with other beams. It increases up to 22% with 2 layer of aluminium alloy and 52% of 3 layer of aluminium alloy.
- The deformational characteristics were generally enhanced for strengthened beams compared with the conventional beam. The mid span deflection for 3 layer of aluminium alloy and the 2 layer of aluminium alloy is increased by 28% and 3% respectively over the RC conventional beam
- Based on the result investigation the flexural strength for beam with3 layers of aluminium alloy plates at bottom shows 52% increase when compared with the RC conventional beam. Then, the beam with 2 layers of aluminium alloy shows 24% increase when compared with the RC conventional beam.
- The results of investigation clearly shows that the viability of using aluminium alloy plates at bottom as an alternative to the prevailing external strengthening technique.
- The analytical and experimental results are correlating with each other.

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