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Numerical Study on the behaviour of CPVC-AL-CPVC Pipes as Reinforcement in Exterior Beam-Column Joint

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Abstract : For reinforcement of concrete, the steel plays a vital role. But the steel bars are easily affected by corrosion. To overcome this, various replacement techniques are carried in the reinforcement. In this paper, reinforcement is replaced with CPVC-AL-CPVC pipes and steel stirrups are provided and its behaviour is studied. Due to the nature of CPVC-AL-CPVC pipes, the corrosion resistant and strength parameter of beam-column joint can be increased. The load deflection and stress-strain behaviour are analysed. The purpose of this study is to perform numerical investigation in order to study the behaviour of exterior RC beam-column joint with CPVC-AL-CPVC pipes. Concrete mix of M20 grade has designed as per IS 10262-2009. A Finite Element Model has been developed using ANSYS software and results were compared between CPVC-AL-CPVC pipes and TMT rods are studied. In this paper, the durability and corrosion resistant of concrete reinforcement replaced with CPVC-AL-CPVC pipes and TMT rods as a composite construction are studied.
Keywords : CPVC-AL-CPVC pipes, TMT rods, durability, corrosion resistant and finite method.

1.0 Introduction

Reinforced concrete is relatively low tensile strength and ductility are counteracted by the inclusion of reinforcement having higher tensile strength or ductility[4,5]. Reinforcing schemes are generally designed to resist tensile stresses in particular regions of the concrete that might cause unacceptable cracking and/or structural failure.

Modern reinforced concrete can contain varied reinforcing materials made of steel, polymers or alternate composite material in conjunction with rebar or not. Reinforced concrete may also be permanently stressed in compression, so as to improve the behaviour of the final structure under working loads.

Reinforced concrete is an important material often preferred to steel construction mainly due to its versatility, adaptability and resistance to fire and corrosion resulting in negligible maintenance costs.

CPVC-AL-CPVC is composite pressure tubing with a welded aluminium tube reinforcement between the inner and outer layers. The inner and outer CPVC layers are bonded to the aluminium tube by a melt adhesive.

1.1 Beam – Column Joint

The beam- column joint is defined as the portion of column within the depth of the deepest beam that frames into column[3]. In other words, portion of columns that are common to beams at their intersection are

called beam-column joint. The beam-column joints are critical sub assemblages in reinforced concrete framed structures as they ensure the contributing of a structure & transfer forces from one element to another3.In Exterior joints where beams terminate at columns, longitudinal beam bars need to be anchored into the column to ensure proper gripping of bar in joint. Repairing damaged joint is difficult so damage must be avoided and thus beam- column joints must be designed to withstand external forces. The joints should have adequate strength and stiffness to resist the internal forces induced by the framing members.

1.2 Finite Element Method

The Finite Element Method (FEM) is a numerical analysis for obtaining approximate solutions to a wide variety of engineering problems. Nowadays, experimental based analysis has been widely used to find the behaviour of beam-column joint and its strength under loading. The usage of finite element analysis has been increased due to cost effective and time consumption. Finite element method is used to develop model to stimulate the behaviour of full size beam-column joint through nonlinear response. Finite element analysis is used in structural engineering, to determine the overall behaviour of the structure by dividing it into a number of simple elements, each of which has well-defined mechanical and physical properties. It helps in the investigation of the behaviour of the beam-column joint before and after the loading conditions, its load deflection behaviour and the crack pattern. In addition, the results of finite element models have to be evaluated by comparing them with experiments of full-scale specimen of beam-column joint.

2.0 CPVC-AL-CPVC Pipes

Highly reliable, multilayer pipe combines the corrosion-resistant benefits of chlorinated polyvinyl chloride (CPVC) from Lubrizol with the strength and durability of aluminium. Multilayer pipe is completely resistant to the oxidative degradation of chlorine[1,2]. Chlorinated polyvinyl chloride pipe well known, as bendable multi-layered pipe that has a good tensile property similar to steel rebar. Hence, due to the enhancing property it can be used as a partial or full replacement of steel rebar in reinforced concrete structures.

2.1 Benefits

1. Reduced overall dead weight.
2. Improved corrosion resistance.
3. Cost more or less the same but effective by its properties.
4. 7.5 times lesser weight than steel rebar

2.2 Material Properties of the CPVC-AL-CPVC Pipes

1. Modulus of elasticity – 70 MPa.
2. Possion's ratio – 0.3.
3. Yield strength – 240 MPa.

2.3 Reinforcement Detailing

The size of the beam was 800mm X 200 mm X 150 mm and column 1000mm X 200 mm X 150mm. The dimension and reinforcement details of test assemblages are shown in fig 1

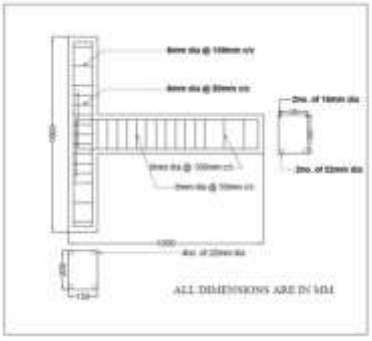


Fig.1. Reinforcement detailing

3.0 Modelling of Beam-Column Joint in Ansys

3.1 General

By using ANSYS we can solve two kinds of problem 1.structural 2.Nonstructural. The structural based problem can be solved by Newton's Raphson method .Here the displacement at each node is found. By making use of the displacement the stresses and strains were found. In non-structural problem we can solve thermal, Electro - magnetic and electrical problems**.**

3.2 Geometrical Modelling

The size of the concrete beam was 800mm X 200 mm X 150 mm and concrete column 1000mm X 200 mm X 150mm.

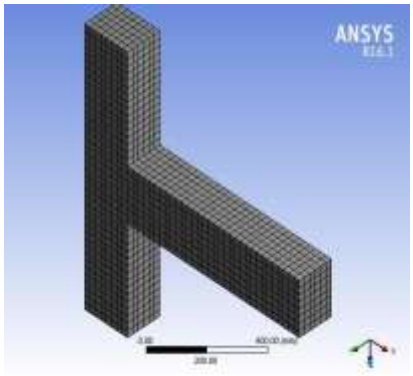


Fig. 2. Geometric model

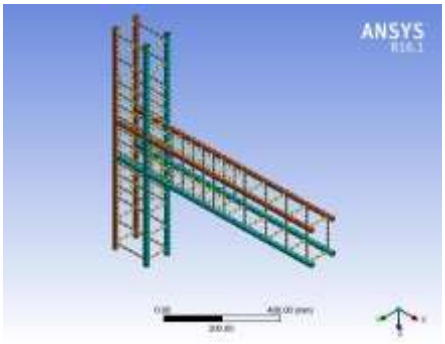


Fig. 3 Reinforcement model

3.3 Characteristic Soffinite element Model

In concrete model, by using SOLID 65 element is the nonlinear material property and also the capability of cracking and crushing of the concrete have been considered. In ANSYS software, CPVC-AL-CPVC pipes can be specified for the following elements: LINK180, BEAM188 & BEAM189. Besides, the number of node and order are the same in both elements LINK180 and SOLID 65; both LINK180 and LINK8 can be used to 3-D modeling. Since the details of both CPVC-AL-CPVC pipes and steel reinforcement must be changed frequently, using LINK180 element is used as reinforcements provides in modeling process.LINK8 element has been used here for stirrups modeling of concrete beam. Hexahedral-shaped elements have been used to mesh the model.

3.4 Loading Condition

In this paper, Cantilever beam is studied under cyclic loading condition.

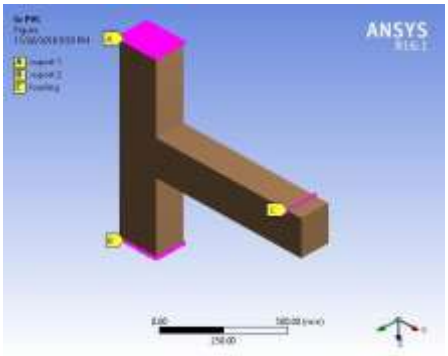


Fig. 4. Loading condition

4.0 Analysis of Beam-Column Joint and Numerical Result

4.1 General

In this project, the load deflection and stress-strain curves were compared between various beam-column joints, such as

1. Reinforcement is provided as TMT rods.
2. Reinforcement fully replaced with CPVC-AL-CPVC pipes.
3. Reinforcement partially replaced with CPVC-AL-CPVC pipes.
4. As a composite construction, reinforcement replaced with CPVC-AL-CPVC pipes & TMT rods.

Stress Strain Curve

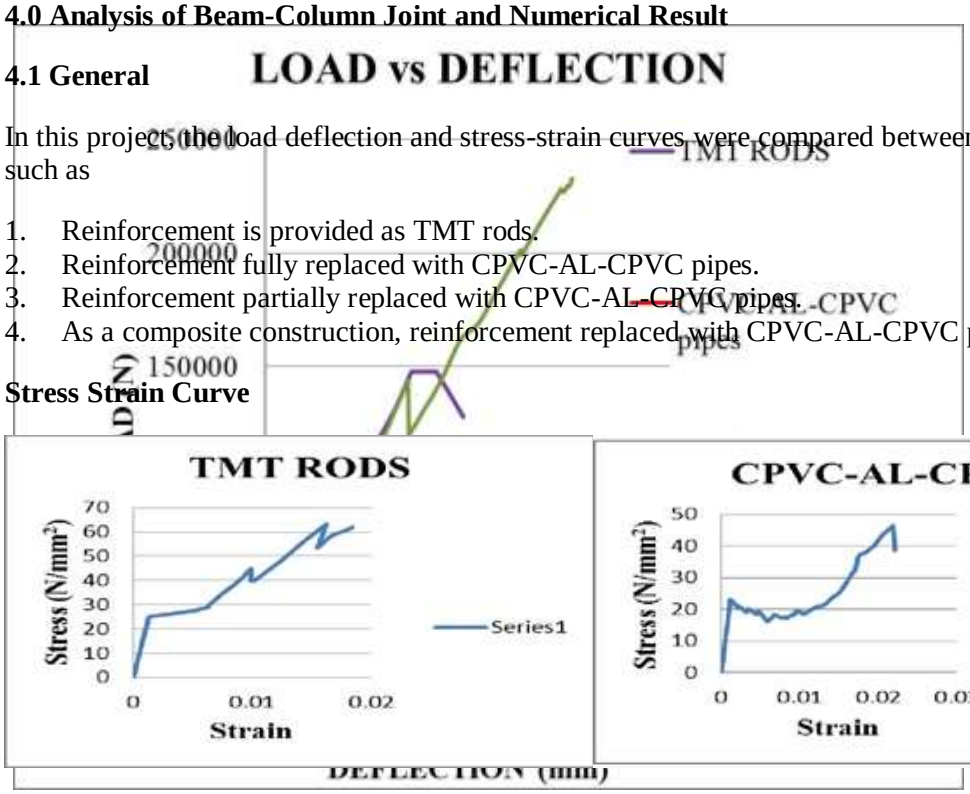
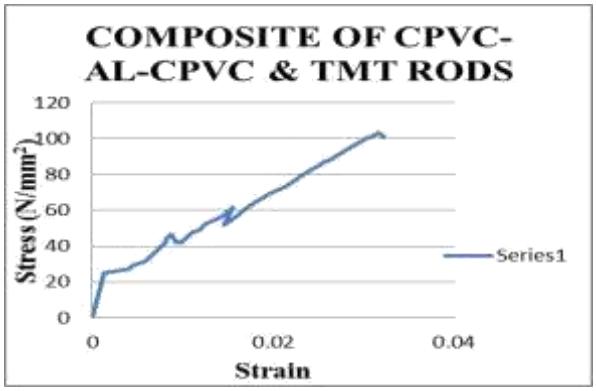


Fig. 5.For TMT rods

Fig. 6. For CPVC-AL-CPVC pipes



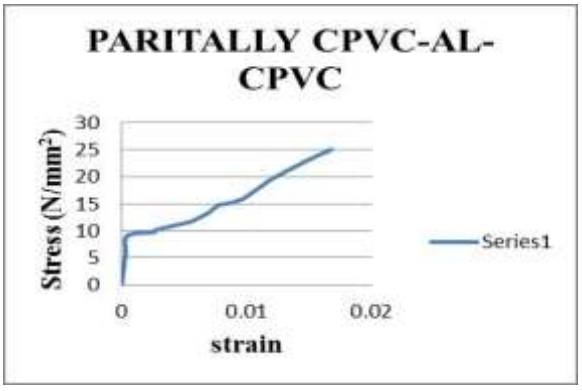


Fig. 7.For partially replaced CPVC-AL-CPVC PipesFig. 8. For composite construction of CPVC-AL-CPVC pipes and TMT rods

From the four types of beam - column joints,

1. The load carrying capacity of TMT Rods is 148 KN.
2. The load carrying capacity of fully replaced of CPVC-AL-CPVC pipes is34 KN (i.e.,) 0.77 times lesser to that ofTMT rods.

4.2 Results

1. The load carrying capacity of partially replaced of CPVC-AL-CPVC pipes is 12kN (i.e.,) 0.92 times lesser to that of TMT rods.
2. The load carrying capacity of composite construction of CPVC-AL-CPVC Pipes and TMT rods is 233kN (i.e.,) 1.6 times higher to that of TMT rods.

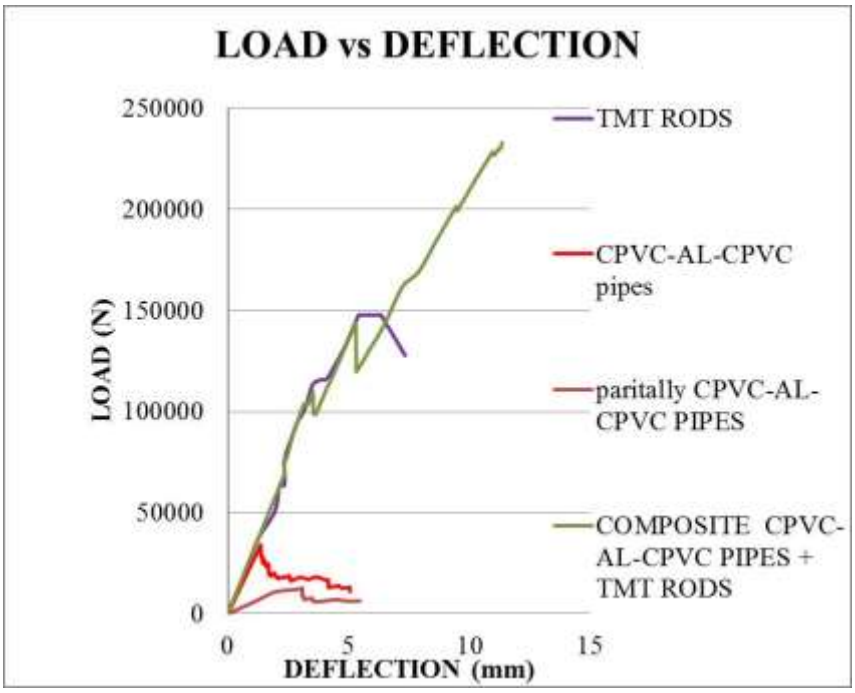


Fig. 9. Load vs Deflection curve

From the results obtained, reinforcement replaced with CPVC-AL-CPVC pipes & TMT rods as a composite construction, proved to be more durable as well as a better corrosion resistant.

5.0 Conclusion

Based on the analytical and experimental work reported in this study, the following conclusions are made

1. The tensile strength of CPVC-AL-CPVC pipes and TMT rods rebars found satisfactory.
2. The load taken by steel reinforcement beam-column joint was greater when compared to fully and partially CPVC-AL-CPVC beam-column joint.
3. Deflection and load carrying capacity is more in composite construction of CPVC-AL-CPVC and TMT rods beam-column joint but had a property of non-collapsing of the concrete and corrosion resistant.

Abbreviations:

CPVC-AL-CPVC: Chlorinated Polyvinyl Chloride/Aluminium/Chlorinated Polyvinyl Chloride,FEM: Finite Element Method, TMT: Thermo mechanical treatment.

6.0 References

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