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Numerical Study on Strengthening Surface Corroded Partially Enclosed Beam by Web Extending

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***Abstract*— The principal cause of deterioration of composite structures is the corrosion of embedded steel bars. The most obvious effect is the reduction in cross-sectional area of the affected steel bars. The transfer of water, oxygen and other agents such as carbon dioxide and chloride, leads to cracking, spalling and deterioration of concrete. Composite structures are made up of two or more different materials. The main benefit of composite elements is combining the properties of each material to form a single unit. Partially enclosed beam is also a composite member. This project present Corrosion and strengthening assessment of partially enclosed beam (PEB). The static analysis of partially enclosed beam was performed and discuss the effect of corrosion on PEB beam in terms of strength and provide web extending to strengthen the corroded beam**.

Keywords*— *Deterioration; composite structure; partially enclosed beam; web extending

I. INTRODUCTION

The composite member system offers a quicker construction process and thinner floor depths that reduce building height, as a result, looking better for high fire ratings, and providing better corrosion protections for the steel beam. Other advantages of composite members include the following: less deflection due to greater stiffness under working loads, increased fatigue and impact resistance as compared to ordinary steel members. Corrosion is considered to initiate when the chloride concentration around the reinforcement reaches a threshold to cause dissolution of the protective film. When the corrosion of steel bars develop significantly, it not only affects the structural serviceability by cracking, or even spalling of the concrete cover, but also has an impact on the structural safety by decreasing the load-bearing capacity of reinforcement concrete members, which is of great concern to both owners and users of the structural building.

II. OBJECTIVES

- To model the partially enclosed beam with varying surface corrosion
- To study the behavior of RC beam strengthened by web extending.

III. SUMMARY OF LITERATURE REVIEW

Composite construction employs structural members that are composed of two materials: structural steel (rolled or built-up) and reinforced concrete. Partially encased steel beam with and without web openings is an efficient technique for the enhancing its flexural capacity. [1] Composites beams are traditional design concepts and made possible an unparalleled range of new and exciting possibilities as viable materials for construction. [2] Introducing web openings to composite beams leads to an enhancement in the ultimate load. Study the the mechanical characteristics of corroded beams in relation to the state of corrosion of the steels, and to compare it with the behavior of non-corroded control elements. [4] There are different methods to strengthening the corroded partially enclosed composite beams. But they are very much expensive, so in order to reduce the cost and also increase the strength of PEB by web extending.[3]

IV. NUMERICAL ANALYSIS

The static analysis of surface corroded RC beam were performed using ANSYS 16.1 WORKBENCH a finite element software for mathematical modelling and analysis.

A. Material properties

The material properties of the partially enclosed beam are tabulated in Table 1.

TABLE I. MATERIAL PROPERTIES

Element Type	Material Property
Beam 188	Young's modulus=200381MPa Poisson's ratio=0.3 Yield strength=235 MPa

B. Base model

Numerical modelling of partially enclosed composite beams with varying surface corrosion were done using ANSYS 16.1 WORKBENCH. The details of partially enclosed beam is given in Table 2.

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TABLE II DETAILS OF PARTIALLY ENCLOSED BEAM

Sample	
Percentage of steel (%)	3%
Width of beam (b) (mm)	200
Depth of beam (d) (mm)	300
Width of top flange (mm)	100
Thickness of top flange (mm)	5
Width of bottom flange (mm)	200
Thickness of bottom flange (mm)	5
Height of web (mm)	230
Thickness of web (mm)	3
Number of web openings	6
Diameter of web openings (mm)	125

The structural performance of partially enclosed composite beams were done under varying surface corrosion (25%, 50% and 75%). The input data for details of specimen are shown in Table 2.

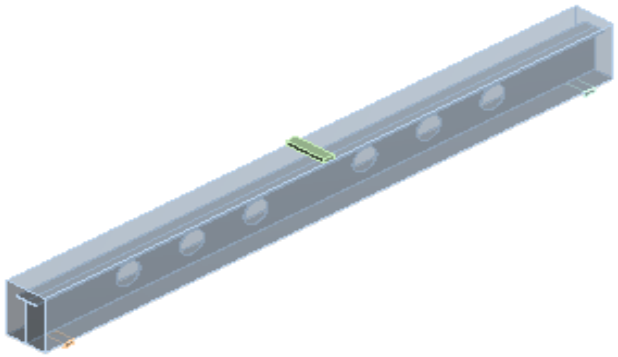

Fig. 1 PEB with 25% surface corrosion

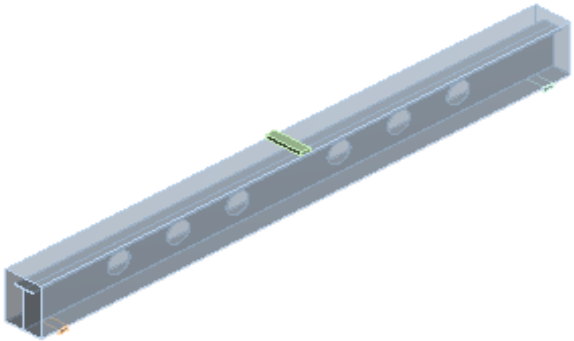

Fig. 2. PEB with 50% surface corrosion

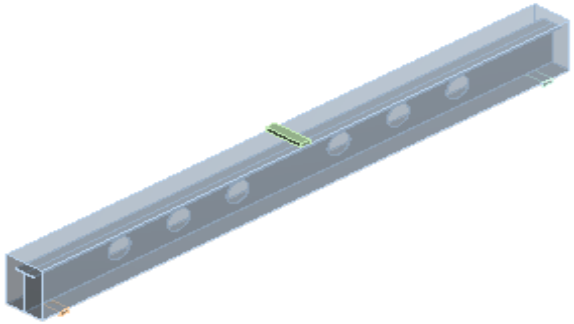

Fig. 3 PEB with 75% surface corrosion

C. Load deflection analysis

The load deflection curve of partially enclosed beam with varying surface corrosion are shown in fig 4. The maximum load deflection for composite beam with 75% surface corrosion is more than that of 25% and 50% surface corrosion. It is observed that the partially enclosed beam with 25% surface corrosion shows maximum load carrying capacity with lower displacement value compared to other surface corrosion (25%, 50%). Partially enclosed beam with 75% surface corrosion shows minimum load carrying capacity.

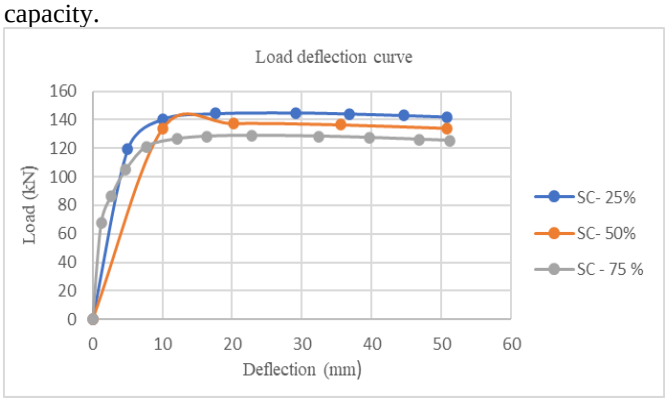

Fig. 4. Load deflection curve of partially enclosed beam with 25%, 50% and 75% surface corrosion

D. Strengthening of partially enclosed beam by web extending

From the above result partially enclosed beam with 75% surface corrosion were the worst condition. To strengthen the partially enclosed corroded beam by extending the web throughout the length of the beam having 5mm width and 25mm depth.

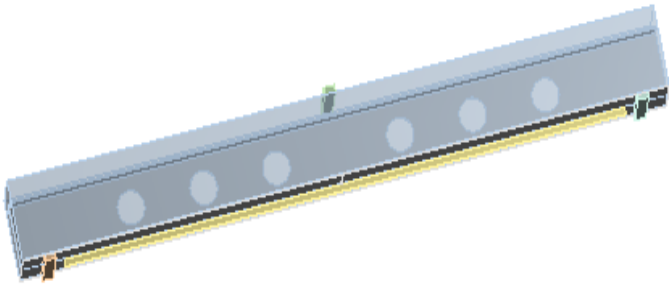

Fig. 5 Web extending of PEB with 75% surface corrosion

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E. Load deflection behavior

The load deflection curve of partially enclosed beam with 75% surface corrosion and web extended 75% surface corrosion are shown in fig 5.

TABLE III LOAD DEFLECTION VALUES

Sl. No:		Max. load (kN)	Deflection (mm)
1	PEB with 75% surface corrosion	128.85	22.841
2	Web extended PEB with 75% surface corrosion	133.51	28.278

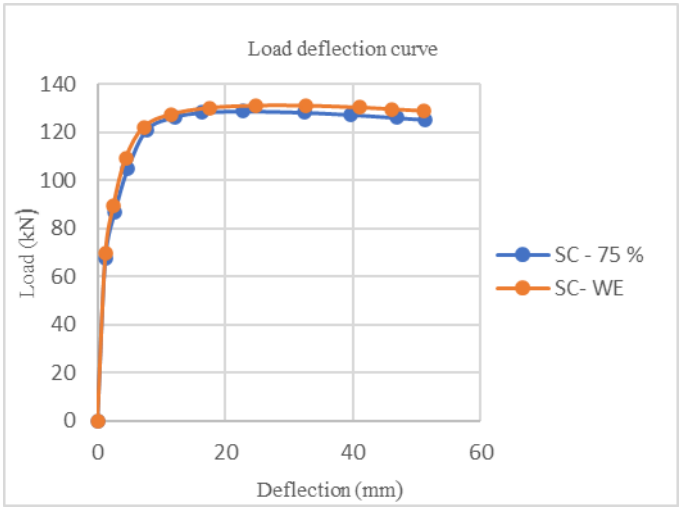

Fig. 5. Load deflection curve of partially enclosed beam with 25%, 50% and 75% surface corrosion

It is observed that the web extended partially enclosed beam with 75% surface corrosion shows maximum load carrying capacity with lower displacement value compared to partially enclosed beam with 75% surface corrosion. Table 3 gives the maximum load taken by each beam and there corresponding deflections

V. RESULTS AND DISCUSSIONS

From the load deflection analysis as shown in fig 4, it is observed that partially enclosed beam with 25% surface corrosion shows maximum load carrying capacity with lower displacement value compared to partially enclosed beam with 50% and 75% surface corrosion. Maximum load acting on 25%, 50% and 75% surface corrosions are 144.97 kN, 137.49 kN and 128.85 kN. From the result partially enclosed beam with75% surface corrosion shows the worst condition. The corrosion formed in composite beam, replacing the existing structures with the new structures are not economically cost effective, therefore finding an appropriate solution for repairing and strengthening the existing structures has a great importance. Web extending are one of the methods to strengthened the surface corroded beam. The load deflection analysis as shown in fig 5, it is observed that web extended partially enclosed beam with 75% surface corrosion shows maximum load carrying capacity with lower displacement value compared to partially enclosed beam with 75% surface corrosion. Web extending is an effective method to increase the strength of surface corroded beam.

VI. CONCLUSIONS

The structural performance of partially enclosed beam under static loading with different percentages of surface corrosions are analyzed and provide an effective method to strengthen the beam and compared. The main conclusions are arrived as follows.

- From the load deflection analysis, it is found that partially enclosed beam with 25% surface corrosion shows maximum load carrying capacity with lower displacement value compared to partially enclosed beam with 50% and 75% surface corrosion.
- From the result partially enclosed beam with75% surface corrosion shows the worst condition. The corrosion formed in composite beam, replacing the existing structures with the new structures are not economically cost effective, therefore web extending are one of the methods to strengthened the surface corroded beam.
- From the load deflection analysis, it is found that web extended partially enclosed beam with 75% surface corrosion shows maximum load carrying capacity with lower displacement value compared to partially enclosed beam with 75% surface corrosion. Web extending is an effective method to increase the strength of surface corroded beam.

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