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Retrofitting of Simply Supported RC Rectangular Beam by Near Surface Mounted Technique

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Abstract*— In this experimental investigation we had retrofitted RC beam by Near Surface Mounted (NSM) technique. To find out percentage increase in flexural strength of beam. We had use two-point load test on it. We casted and retrofitted RC beam of size 700*150*150 mm. To increase flexural strength, we retrofit with the help of FE500 bars of diameter 6mm externally by Near Surface Mounted (NSM) Method. The FE500 bars are applied in different length like 12d, 24d and full length. For fixing the bar we had use epoxy MYK ANCHOR HF 66. we retrofit the bar in different groove sizes like 1.5d and 2d (d is diameter of FE500 bar)

In this experimental study we compare results in flexural load as well as in deformation format. The test result shows that flexural strength of beam was increased when groove size and diameter of bar is increases. A parametric study was conducted to examine the effect of type, number, diameter of FE500 bars and bond length on flexural response. Also study was conducted changes in ultimate load carrying capacity of the retrofitted beams due to effect of groove size and bonded length of bar. Some studied parameters affected the flexural strength and deflection of beam models. Retrofitting by FE500 bar increase flexural strength of beam by 33.10% than regular RC beam, where deflection is ranges between 3.6 mm to 4.6 mm the first crack is developed on retrofitted beam. The first crack is seen at the load ranges between 37.12 to 40.00 kN. which take average load 38.60 kN safely. Retrofitting by NSM technique increases the strength of damaged member and increasing the lifespan of structure. this technique has more future scope because saving the cost of maintenance.

***Keywords*— Near Surface Mounted (NSM) technique, Retrofitting , flexural strength , FE500 bar, groove sizes, bond length**

I. INTRODUCTION

Reinforced concrete structures all over the world require retrofitting or rehabilitation at some in their life span because of various reasons such as change in structural design, mechanical damage, environmental effects, change in service loads, and errors in design and construction. There are a number of methods for retrofitting existing reinforced concrete structures. Externally bonded reinforcement (EBR) and the near surface mounted (NSM) technique are among the most popular retrofitting method. Concrete is material that is very strong in compression, but relatively weak in tension. Therefore, rebar also known as reinforcing steel is a steel bar used as a tension device in reinforced concrete to retrofit and hold the concrete in tension. Most steel reinforcement is divided in to primary and secondary reinforcement there are other minor uses such as rebar may also be used to hold other steel bars in the correct position to accommodate their loads. The physical properties of steel bars and wires for use as reinforcement in concrete shall conform with IS 1786:2008. The standard covers strength grades like FE415, FE415D,FE415S, FE500, FE500D, FE500S, FE550, FE550D and FE600.

A number of experimental studies have investigated the flexural behaviour of RC beams strengthened with NSM bar materials. FRP reinforcement has various advantages such as high strength, light weight, resistance to corrosion and potentially high durability but is highly expensive and not readily available. On the other hand, steel bars are readily available, less expensive, show adequate ductility, long-term durability and bond performance. NSM strengthening using steel bars has been used on masonry buildings and arch bridges. Almusallam et al. investigated the experimental and numerical behaviour of RC beams strengthened in flexure with NSM steel and found that NSM bars promoted the flexural capacity of RC beams.

II. NEAR SURFACE MOUNTED (NSM) TECHNIQUE

In this study we had investigate experimental flexural analysis of RC retrofitted rectangular beam by Near Surface Mounted (NSM) FE500 bars with different bonded length, different groove sizes as well as different diameter of the FE500 bars.

In this technique firstly we had casted beam of size 700*150*150 mm then after twenty-eight days, all the beams will be turned the other way up to be ready for mark for the grooves. The locations of the groove were initially to be mark on the tension side of the beams. A hammer and chisel will be used for making grooves.

A silk brush will be used to clean the groove and avoid entry of air and water and make sure that the groove is totally clean. The epoxy will be injected into the groove to height 2/3 of the groove depth. The FE500 bar will be gently inserted into the groove. The bar will be gently inserted without displacing the bonding agent.

III. CASTING AND TESTING OF REINFORCED CONCRETE BEAM

We had design RC beam with the help of I.S 456-2000 and I.S 875 part-II. For this experimental purpose we had casted twenty eight no. of beam. Out of that three are tested without retrofitting and reaming are retrofitted with different groove size and different bonded length. We tested beam to find out increase in flexural strength capacity of retrofitted beam. We use 6 mm dia. of bar to retrofit beam. For testing purpose we had use two point loading method and beam has been tested under UTM.

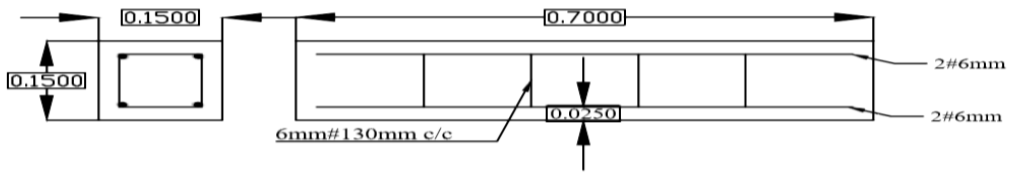

Fig.1 Detailing of RC Beam

Fig.2 Testing of RC Beam

Fig.3 Testing of Retrofitted Beam

A) TEST RESULT OF RC BEAM:

TABLE I
FLEXURAL STRENGTH OF RC BEAM.

Sr. No.	Size of Beam(mm)	Span (mm)	Applied load (kN)	Deflection (mm)	Flexure strength (N/mm^2)	Avg. Flexural Strength (N/mm^2)
1	700×150×150	600	41.56	11	7.20	7.58
2	700×150×150	600	49.28	12.5	8.54	
3	700×150×150	600	39.96	7.2	7	

TABLE III

TEST RESULT OF RC BEAM

Load (kN)	Deflection (mm)
0	0
10	1.28
20	2.75
30	5.33
40	8.12
41.56	11

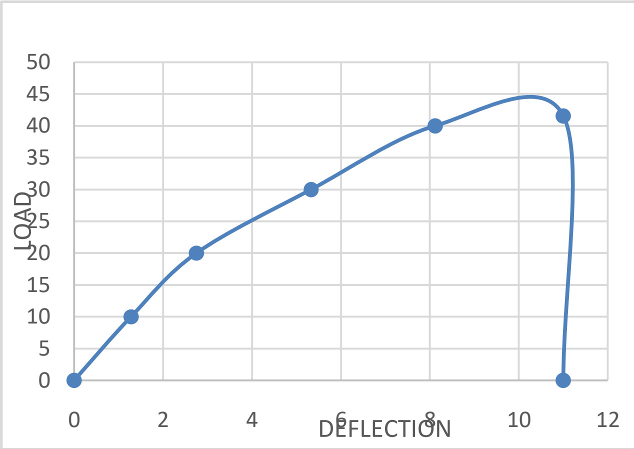

Fig.4 Deflection Vs load for RCC beam

B) TEST RESULT OF RETROFITTED BEAM :

TABLE IIIII

FLEXURAL STRENGTH OF RETROFITTED BEAM

Size of Bar	Specimen (groove Size)	Bonded length	Applied Load (kN)	Deflection (mm)	Flexural Strength (N/mm^2)	Avg. Flexural Strength (N/mm^2)
6 mm	1.5d	12d	49.94	14.51	9.76	9.85
			56.36	14.49	9.77	
			52.46	13.28	10.02	
		24d	56.64	8.18	10.57	9.78
			53.78	7.49	9.08	
			54.52	10.20	9.69	
		Fully Bonded	70.56	5.82	12.66	12.46
			65.28	4.8	11.79	
			69.36	5.20	12.94	
6 mm	2d	12d	55.74	13.52	10.9	10.13
			57.92	14.92	10	
			56.24	12.48	9.49	
		24d	63.04	9.52	10.92	11.69
			68.80	10.42	12.23	
			65.50	10.11	11.93	
		Fully Bonded	79.98	6.91	15.5	14.16
			72.28	5.80	13.63	
			76.50	6.20	15.3	

Test result of 6mm diameter bar having groove size 1.5 times of diameter and bonded length 12 times of diameter

TABLE IVV
TEST RESULT OF 6MM-1.5D-12D

Load (KN)	Deflection (mm)
0	0
10	1.14
20	2.57
30	4.62
40	8.74
50	11.23
56.36	14.49

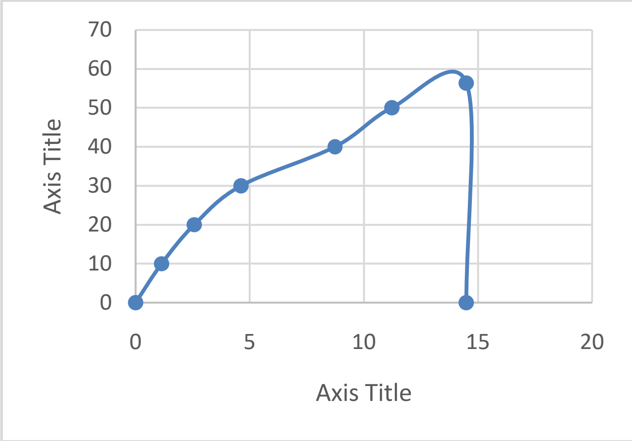

Fig 5 load vs Deflection 6mm -1.5d -12d

Test result of 6mm diameter bar having groove size 1.5 times of diameter and bonded length 24 times of diameter

TABLE VV
TEST RESULT OF 6 MM-1.5D-24D

Load (KN)	Deflection (mm)
0	0
10	0.91
20	1.43
30	2.96
40	4.53
50	6.18
56.64	8.18

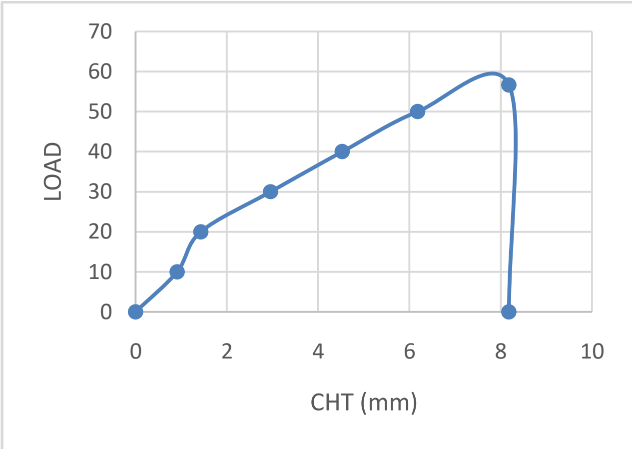

Fig 6 load vs Deflection 6mm -1.5d -24d

Test result of 6mm diameter bar having groove size 2 times of diameter and bonded length 12 times of diameter

TABLE VI
TEST RESULT OF 6MM-2D-12D

Load (KN)	Deflection (mm)
0	0
10	1.26
20	2.57
30	4.88
40	6.96
50	10.69
57.92	14.92

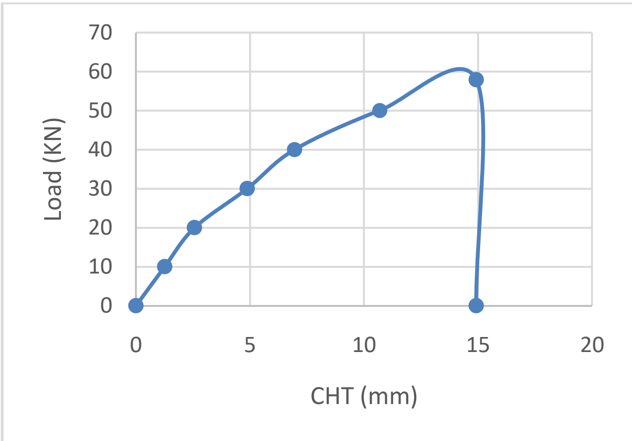

Fig 7 load vs Deflection 6mm -2d -12d

Test result of 6mm diameter bar having groove size 2 times of diameter and bonded length 24 times of diameter

TABLE 7.3.4 TABLE VII
TEST RESULT OF 6MM-2D-24D

Load (KN)	Deflection (mm)
0	0
10	0.75
20	1.51
30	2.25
40	3.17
50	5.31
60	7.50
68.80	10.42

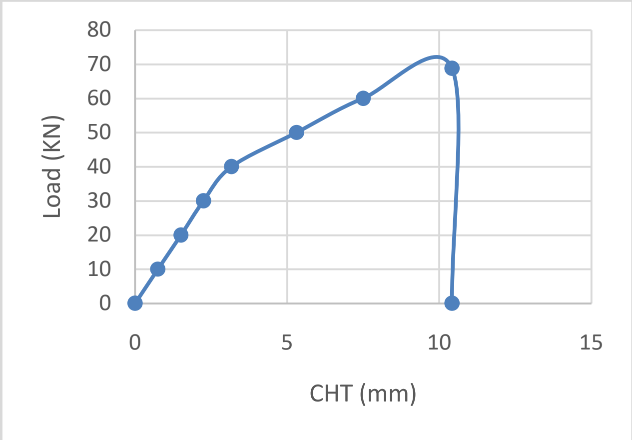

Fig 8 load vs Deflection 6mm -2d -24d

7.3.9 Test result of 6mm diameter bar having groove size 1.5 times of diameter and Fully bonded length

TABLE VIII
TEST RESULT OF 6MM-1.5D-FULLY

Load (kN)	Deflection (mm)
0	0
10	0.39
20	0.82
30	1.17
40	1.92
50	2.56
60	3.71
70	4.78
70.56	5.82

BONDED

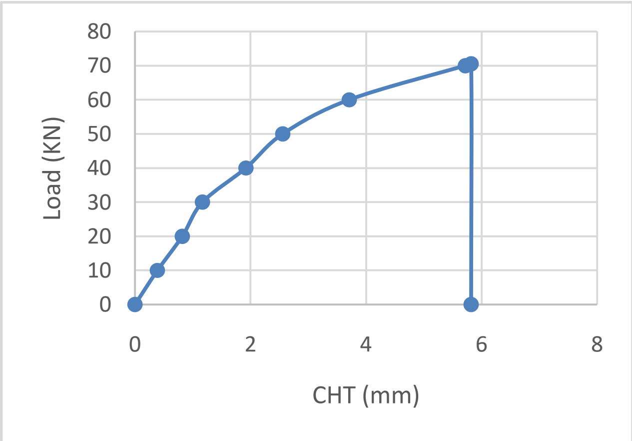

Fig 9 load vs Deflection 6mm -1.5d –fully bonded

Test result of 6mm diameter bar having groove size 2 times of diameter and fully bonded length

TABLE IX
TEST RESULT OF 6MM-2D-FULLY BONDED

Load (KN)	Deflection (mm)
0	0
10	0.42
20	0.86
30	1.3
40	2.32
50	3.47
60	4.63
70	5.85
79.98	6.91

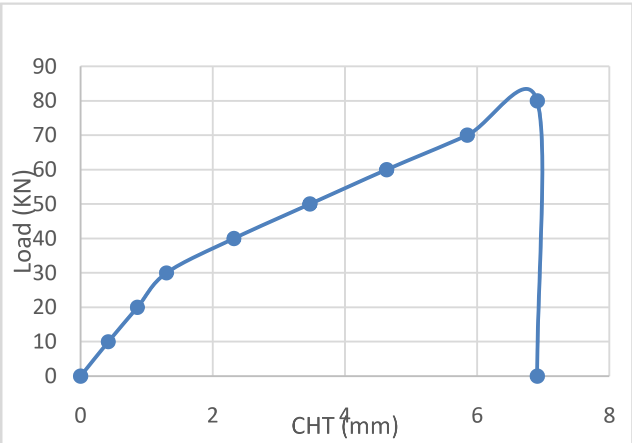

Fig 10 load vs Deflection 6mm -2d – fully bonded

TABLE X

INCREASED FLEXURAL STRENGTH OF BEAM AFTER STRENGTHENING

Groove size (mm)	Size of bar (mm)	Bonded length (mm)	Increased flexural strength in %
1.5d	6mm	12d	23.04
		24d	20
		Fully bonded	39.16
2d	6mm	12d	25.17
		24d	35.15
		Fully bonded	46.46

It is observed that, after retrofitting of RC beam with fully bonded length takes 3.10 times more load before collapse. From deflection point of view RC beam have more deflection than retrofitted beam. The fully bonded retrofitted beam having deflection in between 4.5 to 6.81 mm. RC beam having deflection in-between 3.0-3.1 mm.

From the comparison it is found that after retrofitting the beam takes 3.1 times more load safely and having more deflection as compare to RC beam. When loading was increased the width of crack is increased and splitting of concrete is occurred. From above experimental study we can say that, retrofitting of RC Beam by using FE500 bar is better and economical than demolition of beam structure.

IV. CONCLUSIONS

In this experimental work attempt is made to find out relation between ultimate load carrying capacity and deflection of beam after retrofitting by FE500 bar. For which we had use structural design procedures and different IS codes in a convenient manner. From this experimental work following conclusions are drawn:

- Strengthening by FE500 bar increase flexural strength of beam by 33.10% then regular RC beam.
- When deflection is ranges between 3.70 mm to 4.65 mm the first crack is developed on retrofitted beam.
- The first crack is developed at the load in between 37.10 to 40.20 kN. which take average load 38.40 kN safely.
- For retrofitting by FE500 bar required up to 90 % less cost as compared to FRP bar.
- The mode of failure is flexural failure for all retrofitted beams.
- We conclude that when bonded length increases, the load carrying capacity of specimen also increases.
- The retrofitted beam has higher strength and deformation as compared to RC beam.
- Retrofitted beam has been fail in the form of spiting of concrete and change in position of reinforcement.

REFERENCES

1) Slobodan Rankovie, Radomir Folic, Marina Mijalkovie, *EfFEcts of RC beams reinforcement using near surface mounted reinforcement FRP composites*, Facta Univ., Ser. A & CE 8(2) (2010) 177–185.

2) Adhikary, B.B., Mutsuyosh, H. and Sano, M. (2000), *"Shear strengthening of reinforced concrete beams using steel plates bonded on beam web: experiments and analysis*", Construction and Building materials, vol. 14, pp. 237-244.

3) Diab, Y. G. (1998), *"Strengthening of RC beams by using sprayed concrete: experimental approach", Engineering Structures*, vol. 20, no. 7, pp. 631-643.

4) Garden H. N. and Hollaway L. C. (1998), *" An experimental study of the influence of plate end anchorage of carbon fibre composite plates used to strengthen reinforced concrete beams",* Composite Structures, vol. 42, pp. 175-188.

5) El-Hacha, R. and S.H. Rizkalla, *Near-surface-mounted fiberreinforced polymer reinforcements for flexural strengthening of concrete structures*. ACI Structural Journal, 2004. 101(5).

6) El-Hacha, R. and M. Gaafar, *Flexural strengthening of reinforced concrete beams using prestressed, near-surface-mounted CFRP bars*. PCI journal, 2011. 56(4): p. 134-151.

7) De Lorenzis, L., A. Nanni, and A. La Tegola. *Strengthening of reinforced concrete structures with near surface mounted FRP rods.* in International Meeting on Composite Materials, PLAST 2000, Proceedings, Advancing with Composites. 2000.

8) Badawi, M. and K. Soudki, *Flexural strengthening of RC beams with prestressed NSM CFRP rods–Experimental and analytical investigation.* Construction and Building Materials, 2009. 23(10): p. 3292-3300.

9) Al-Mahmoud, F., et al., Strengthening of RC members with nearsurface mounted CFRP rods. Composite Structures, 2009. 91(2): p. 138-147.

10) Rahal, K.N. and H.A. Rumaih, *Tests on reinforced concrete beams strengthened in shear using near surface mounted CFRP and steel bars*. Engineering Structures, 2011. 33(1): p. 53-62.

11) Garrity, S. *Near-surface reinforcement of masonry arch highway bridges.* in Proceedings 9 th Canadian Masonry Symposium, Fredericton. 2001.

12) Almusallam, T.H., et al., *Experimental and numerical investigation for the flexural strengthening of RC beams using near-surface mounted steel or GFRP bars.* Construction and Building Materials, 2013. 40: p. 145-161.

13) Committee, A., *Building code requirements for structural concrete (318-11) and commentary*-(318R-11). Detroit, Michigan: American Concrete Institute, 2011

14) Kang J. Y., Park Y. H., Park J. S., You Y. J., and Jung W. T, "*Analytical Evaluation of RC beams strengthened with near surface mounted CFRP laminates,"* American Concrete Institute (ACI), Special Publication, vol. 230, no. 45, pp. 779-794, 2005.

15) De Lorenzis L., Nanni A., and La Tegola, *"Flexural and shear strengthening of reinforced concrete structures with Near Surface Mounted FRP rods,"* Proceeding of the 4th international ConFErence on Advanced Composites Materials in Bridges and Structures (ACMBS 2000), J.L. Humar and A.G Razagpur Editors, Canadian Society for Civil Engineering, Ottawa, pp 521-528 (2000).