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A Smart Reinforced Steel Wire Mesh U-Shape Jacketing Technique in Strengthening and Retrofitting RC Beams

Abo-Alanwar, M. M. and Elbatal, S. A.
Civil Engineering Department
Faculty of Engineering, Al – Azhar University
Cairo, Egypt

***Abstract*—Strengthening of existing reinforced concrete (RC) members is of great importance. Many techniques such as concrete jacketing, steel jacketing, steel skeleton and composite (FRP) are used. The present study focuses on strengthening beams subjected to flexure load. A new smart technique by adding external steel bars in tension side of the beam wrapped with steel wire mesh in the form of U shape jacket is presented and examined. A total of twelve specimens having a beam cross section of (100x160) mm with overall length 1280 mm with effective length 1080 mm were tested. Specimens were classified into four groups. Group (I) contains two control specimens (B1 & B2). Group (II) contains four specimens (B3, B4, B5 and B6) were strengthened by wrapping beams with 3 plies of galvanized steel wire mesh in the form of U-shape jacket fixed with 2 clamps. Additional external steel bars 2Ø8, 3Ø8, 4Ø8 and 5Ø8 respectively were placed in the tension side of the beams. Group (III) contains another four specimens (B4, B7, B8 and B9) were strengthened by adding external steel bars 3Ø8 in tension side of the beams wrapped with 3 plies of galvanized steel wire mesh in the form of U-shape jacket and fixed with 2, 4, 6 and 8 clamps respectively. Groups (I), (II) and (III) were tested and loaded monotonically to failure. Group (IV) contains four specimens (B4, B10, B11 and B12) were tested and loaded monotonically to load to 0.0%, 60.00%, 80.00% and 100% respectively of failure load. After that, beams were strengthened by adding external steel bars 3Ø8 in tension side of the beam wrapped with 3 plies of galvanized steel wire mesh in the form of U-shape jacket and fixed with 2 clamps. Beams again were tested and loaded monotonically to failure. The used strengthening technique can significantly enhance the flexural and shearing strength as well as the performance of the RC beams. For the case of beams wrapped with 3plies of steel wire mesh and fixed with 2 clamps, increasing the area of the additional external steel bars (from 2Ø8 to 5Ø8) increases the load carrying capacity from (108% to 136%) and decreases the beam deflection. However, increasing the number of clamps from 2 to 8 slightly increases the ultimate load carrying capacity by (25%) and decreases the beam deflection. In addition, preloading of beams from 0.00 % to 100 % of beam failure load increases the ultimate load carrying capacity of the retrofitted beams from 122% to 110 %.**

Keywords— Beam; Concrete; Strengthening; Retrofitting; Steel Wire Mesh; External Steel Bars; Clamps; U-Shape Jacket; Load Capacity; Deflection; Experimental.

I. INTRODUCTION

Strengthening of existing reinforced concrete (RC) members is of great importance. Many existing reinforced concrete structures are unable to carry existing loads because of many causes such as, construction errors, design mistakes, change of use, increase of live loads and new codes. Saadatmanesh, H. and Ehsani, M.R. (1991) studied experimentally RC beams strengthened with glass-fibre-reinforced-plastic (GFRP) plates under four-point bending. The results indicated that the flexural strength of RC beams can be increased by gluing GFRP plates to the tension face. Chajes, M.J. et al. (1994) strengthened RC beams using three different externally bonded fabrics composite materials. The fabrics used were made of aramid, E-glass and graphite fibres, and were bonded to the beams using a two-part epoxy. The external composite fabric reinforcement led to a 36 to 57% increase in flexural capacity and a 45 to 53% increase in flexural stiffness. The beams reinforced with aramid fabric failed due to the crushing of the compression concrete. Paramasivam, P. et al. (1994) investigated strengthening RC T-Beams by using ferrocement laminates. The ferrocement laminates were attached using 'L'-shaped mild steel round bars as shear connectors. The results showed that use of closely spaced shear connectors and proper surface preparation resulted in improved serviceability and flexural capacities. Norris, T. et al. (1997) presented an experimental and analytical study of the behavior of damaged concrete beams retrofitted with thin carbon fiber reinforced plastic (CFRP) sheets. The CFRP sheets are epoxy bonded to the tension face and web of concrete beams to enhance their flexural and shear strengths. Shin, K.J. et al. (2007) introduced an experimental study on the flexural behavior of RC beams strengthened with high-strength tension bar as external post-tension strengthening materials. The specimens strengthened with V-shaped high-tension bar showed increase in stiffness and strength. Yao, Z.H. et al. (2008) performed an experimental study on flexural behavior of RC beams strengthened with high-strength steel wire mesh and polymer mortar (SMPM). Experiments were conducted to investigate the flexural behavior of 5 RC beams including 4 strengthened specimens and 1 comparative beam. Xing, G. et al. (2010) demonstrated experimental investigation of RC T-beams strengthened with steel wire mesh (SWM) embedded in polymer mortar overlay. Tests were conducted up to failure on one control beam and on four strengthened beams with different load histories. The chosen load histories were 0% and 65% of the control yield moment. The results indicated that the ultimate strength of RC T-beams, strengthened with SWM composites, is almost the same regardless of the load history at the time of strengthening. Kothandaraman, S. and Vasudevan, G. (2010) made an experimental study on flexural retrofitting of RC beams using external bars inserted in anchoring holes at soffit (bottom) level by two methods. In the first method, external reinforcements were fixed to the soffit of the beam as straight bars and tested in single-point loading. However in the second method, the external bars were fixed by cutting the bars into two pieces, anchoring them separately into the beams and tied (lapped) by welding with keeping all other criteria same. Experimental investigation showed that this technique led to, enhanced moment carrying capacity, reduced deflection and crack width and improved ductility. Sen, T. and Reddy, H.N.J. (2011) achieved a numerical study of strengthening of RC beam using natural Bamboo fibres. A nonlinear finite element analysis is carried out in order to evaluate the performance of Bamboo fibres by retrofitting a Plain Concrete Block by using Bamboo fibre reinforced polymer. It was seen that the strengthened specimens exhibit increase in strength, stiffness, and stability. Yudong, L. et al. (2012) carried out an experimental study on flexural behavior of RC and prestressed RC (PRC) beams strengthened with U-shaped high strength steel wire mesh (HSSW) and permeable polymer mortar (PPM). The influences of damage intensity, level of effective prestressing and loading regime on the flexural performance of these strengthened beams were investigated. Vasudevan, G. and Kothandaraman, S. (2013) presented an experimental study on the performance of RC beams strengthened with non-prestressed external reinforcing bars at soffit (bottom) level. The external bars have been chosen as two equaled diameter. Nahar, T.T. et al. (2014) carried out an experimental study on ferrocement performance for repairing of RC beam. Three set RC beams were tested by one point loading system as a simply supported beam until the beam was near to fail then repaired. The first set was repaired by 0.5 inch ferrocement layer on three sides. The second one was subjected to two layers of ferrocement on the bottom of thickness 1 inch and only one layer in a two sides. And the last set was surrounded by total 1 inch ferrocement layer on three sides. Elsamny, M.K. et al. (2015) examined strengthening of beams by using steel wire mesh with different number of plies. The obtained test results showed that increasing the number of wire mesh plies used in strengthening beams increases the load carrying capacity of beams and decreases the mid span deflection. Abd–Elhamed, M. K. (2015) studied experimentally retrofitting of reinforced concrete damaged beams using jacketing of steel wire mesh with steel plates. The investigated parameters were the width of longitudinal steel plates which were added at the bottom of beams inside the steel wire mesh fixed with different number of steel fisher bolts. Ezz-Eldeen, H. A. (2015) introduced an experimental study on retrofitting of damaged reinforced concrete beams using steel wire mesh and steel angles. The beams were retrofitted using two and three external plies of steel wire mesh. The investigated parameters were the size of longitudinal steel angles which were added at the bottom corners of beams inside the steel wire mesh. However, etch above mentioned techniques has at least one or more number of limitations such as high cost, difficulty in execution and de-bonding failure. In the present study a new smart technique to strength and retrofit RC beams by steel wire mesh jacketing with additional external steel bars fixed with clamps is presented.

II. Proposed Techniques Used for Strengthening and Retrofitting of RC Beams

In the present study a new and cheap technique for strengthening RC beams is developed. The used technique is a jacketing technique with different schemes as follows:

- Warping the RC beams only with expanded galvanized three plies steel wire mesh from three sides (i.e. U-shape jacket). Two straps have been provided at the ends and the steel wire mesh jacketing. The steel wire mesh and clamps have been fixed to the beam with fisher polts. The jacket was grouted by cement mortar as shown in figure (1).
- Using the first scheme with different number of external additional horizontal steel bars (2Ø8 up to 5Ø8) in between the plies of the steel wire mesh in the tension side of the beam with two vertical steel clamps.
- Using the first scheme with external additional horizontal steel bars 3Ø8 in between the plies of the steel wire mesh in the tension side of the beam with different number of vertical steel clamps (2,4,6 and 8)

All specimens have been roughened before installing the jacketing as shown in figure (2) in order to insure a good bond between the beams and strengthening or retrofitting jacketing.

Fig. [1-a] Expanded galvanized steel wire mesh U-shape jacket with two straps at the ends.

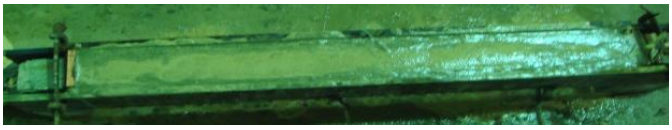

Fig. [1-b] Grouting with jacketing of cement mortar.

Fig. 1. Jacketing technique used for strengthening and retrofitting of RC beams.

Fig. 2. Roughening the strengthened surface of the specimens before installing the jacketing.

III. Used Materials

- Ordinary Portland cement was used in all the experimental work.
- Clean drinking fresh water free from organic matter, silt, oil, sugar, chloride and acidic material is used for mixing and curing the specimens.
- Normal mild steel bars St24/37-smooth rebar's of diameter 6.0 and 8.0 mm were used.

- Crushed stone which has a maximum nominal size of (0.075-19.0mm) was used as the coarse aggregate in the mix.
- Graded sand having sizes in the range of (0.075 - 0.3 mm) was used as the fine aggregate in the mix.
- The concrete mix used in all specimens was designed according to the Egyptian code of practice to obtain target strength of 25 N/mm^2 at the age of 28 days.
- Galvanized welded square steel wire mesh used has a specification 12.7x12.7 mm panel size and 1.6 mm wire diameter.
- Grout cement mortar mixes was 0.65:1:2.5 (water:cement:sand) by weight.
- To improve workability of grout cement mortar, 0.3 % of cement weight of super plasticizer were added (ADDICRETE BV).
- Steel clamps used have a yield stress of 325 N/mm^2 and tensile strength of 420 N/mm^2 with an elongation percentage of 30%.
- Strain gauges used were manufactured by TOKYO SOKKI KENKYUJO CO. LYD. The type used was PFL-30-11-3L, which has a resistance of 120.4 ± 0.5% Ohms and a gauge factor of 2.13 ± 1.0%.

IV. SPECIMENS' GEOMETRY, REINFORCEMENT DETAILS AND LOCATION OF MOUNTED STRAIN GAGUGES

All tested RC beams have been casted with a rectangular cross-section, (100 mm ×160 mm) and 1280 mm overall span (1080 mm effective span) as shown in figure (3). However, all specimens were reinforced with two normal mild steel bars 8 mm diameter as a bottom reinforcement and two normal mild steel bars 6 mm diameter as a top reinforcement. Also, beams were provided with stirrups of normal mild steel 6 mm diameter and 100 mm spacing as shown in figure (4-a). Strain gauges internally mounted on the bottom reinforcement for all specimens as shown in figure (4-a). In addition, strain gauges externally mounted on the additional steel bars as shown in figure (4-b).

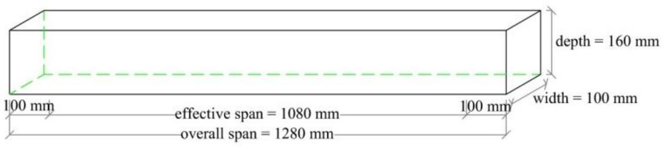

Fig. 3. Details of specimen geometry.

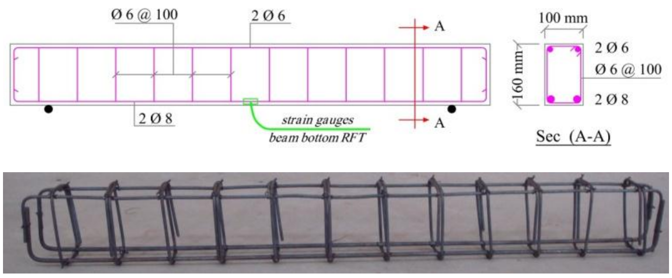

Fig. [4-a] Reinforcement details and location of internal mounted strain gauges for all tested specimens.

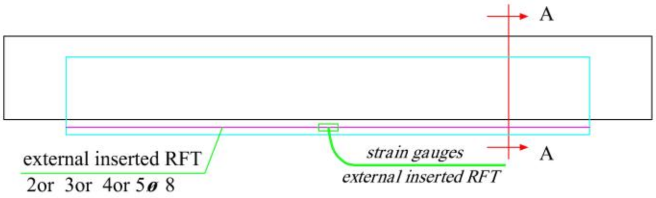

Fig. [4-b] Location of external mounted strain gauges for all strengthened and retrofitted specimens.

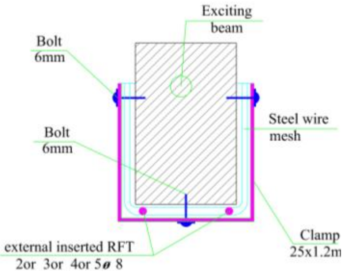

Fig. [4-c] Section A-A.

Fig. 4. Specimens' geometry, reinforcement details and location of mounted strain gaguges.

V. EXPERIMENTAL INVESTIGATION

A total of twelve RC beams with a rectangular cross-section, (100 mm ×160 mm) and 1280 mm overall span (1080 mm effective span) with the same reinforcement have been casted and tested. A number of foil-backed strain gauges were affixed at monitored internal reinforcement. Other strain gauges were also used to monitor strains externally on the external additional horizontal steel bars used for strengthening and retrofitting.

Two reference beams were kept without strengthening and were tested until failure as control specimens. The other specimens were divided into three groups. Group II contains four beams which have been strengthened only by three plies of steel wire mesh jacketing with external additional horizontal steel bars with different numbers 2, 3, 4 and 5Ø8 in between the plies of the steel wire mesh in the tension side of the beam with two vertical steel clamps of 25 mm width and 1.2 mm thickness as shown in figure (5). While group III contains four specimens which have been strengthened only by three plies of steel wire mesh jacketing with 3Ø8 external additional horizontal steel bars. Different number of vertical steel clamps (2, 4, 6 and 8) of 25 mm width and 1.2 mm thickness distributed uniformly were used as shown in figure (6). In addition, group IV contains four beams which have been retrofitted with only by three plies of steel wire mesh jacketing with 3Ø8 external additional horizontal steel bars with two vertical steel clamps of 25 mm width and 1.2 mm thickness. Different pre-loading 0%, 60%, 80% and 100% were applied. Table (I) shows all details of the tested specimens.

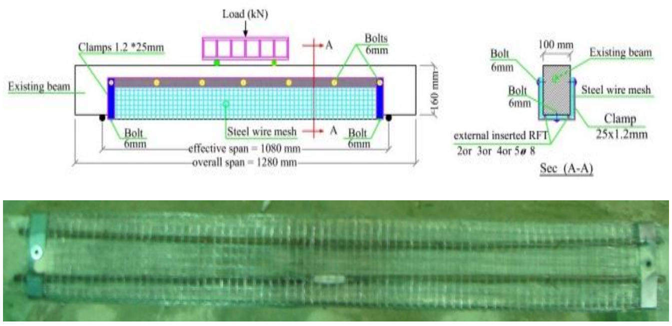

Fig. [5-a] External additional horizontal steel bars 2Ø8 and two vertical steel clamps.

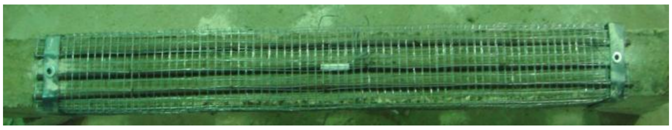

Fig. [5-b] External additional horizontal steel bars 3Ø8 and two vertical steel clamps.

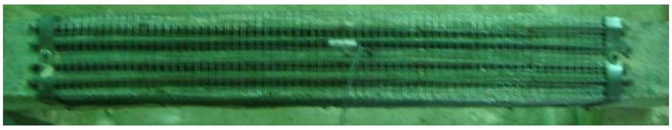

Fig. [5-c] External additional horizontal steel bars 4Ø8 and two vertical steel clamps.

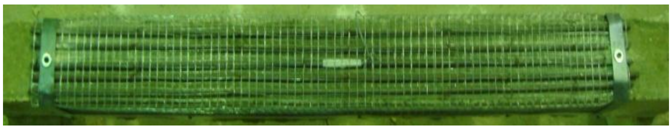

Fig. [5-d] External additional horizontal steel bars 5Ø8 and two vertical steel clamps.

Fig. [5-e] Vertical steel clamps with 25 mm width and 1.2 mm thickness.

Fig. 5. External additional horizontal steel bars with different numbers 2, 3, 4 and 5Ø8 in between the plies of the steel wire mesh in the tension side of the beam and two vertical steel clamps with 25 mm width and 1.2 mm thickness.

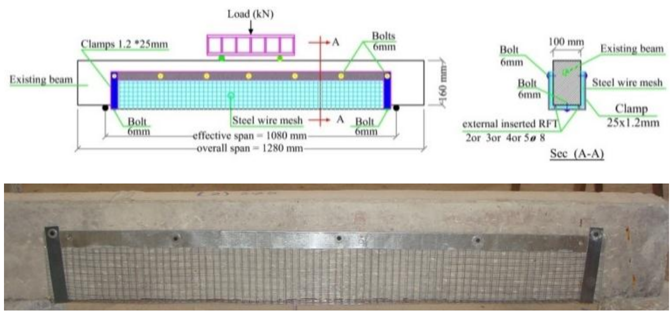

Fig. [6-a] External additional horizontal steel bars 3Ø8 with 2 vertical steel clamps.

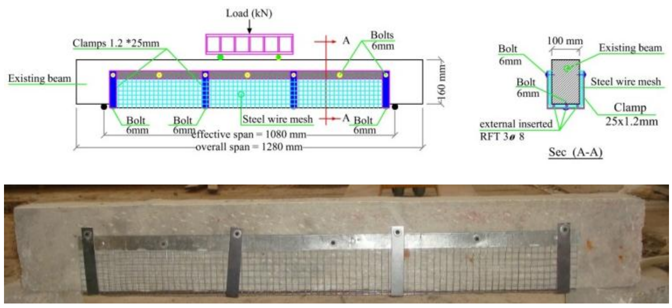

Fig. [6-b] External additional horizontal steel bars 3Ø8 with 4 vertical steel clamps distributed uniformly.

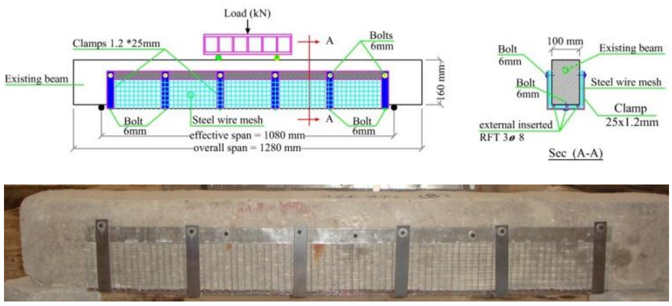

Fig. [6-c] External additional horizontal steel bars 3Ø8 with 6 vertical steel clamps distributed uniformly.

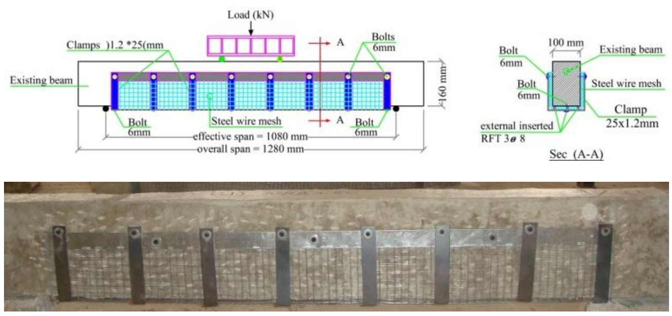

Fig. [6-d] External additional horizontal steel bars 3Ø8 with 8 vertical steel clamps distributed uniformly.

Fig. 6. External additional horizontal steel bars 3Ø8 in between the plies of the steel wire mesh in the tension side of the beam with different number of vertical steel clamps (2, 4, 6 and 8) with 25 mm width and 1.2 mm thickness distributed uniformly.

TABLE I. DETAILS OF THE TESTED SPECIMENS INCLUDING FAILURE LOADS OF ALL TESTED BEAMS

Groups	Specimen No.	Method of Strengthening			Pre-Load before strengthening	Failure load (kN)	Increasing Beam capacity (%) of control
		No. of Plies	*No. of External Horizontal Bars φ8 in Tension Side*	*Total No. of Clamps*			
Group I (control)	B1	No Strengthening (control)				36	--
	B2					36	
Group II	B3	3 Plies of expanded galvanized steel wire mesh from three sides (U-shape jacket)	2φ8	2	0 %	75	108%
	B4		3φ8	2	0 %	80	122%
	B5		4φ8	2	0 %	83	131%
	B6		5φ8	2	0 %	85	136%
Group III	B4		3φ8	2	0 %	80	122%
	B7		3φ8	4	0 %	82	128%
	B8		3φ8	6	0 %	83	131%
	B9		3φ8	8	0 %	84	133%
Group IV	B4		3φ8	2	0 %	80	122%
	B10		3φ8	2	60 %	77	114%
	B11		3φ8	2	80 %	76	111%
	B12		3φ8	2	100 %	75.5	108%

VI. TEST SETUP AND PROCEDURE

All beams were tested as simply supported beams under two points loading using the testing machine mounted on the Material Laboratory of Al-Azhar University which has an ultimate compressive load capacity of 100 kN as shown in figure (7). The beam deflection was measured by three LVDTs placed at the tension side of the beam as shown in figure (8). Data were measured by strain gauge and acquired and filtered electronically using a Keithley-500A data acquisition system, which was controlled by a desktop computer. The specimens were cured for 7 days from the date of casting of grout jacketing. The tests were terminated by complete destruction of the beam specimen as shown in figure (9). In case of retrofitting, total removed of damaged parts were replaced by grout mortar.

Fig. 7. Testing machine.

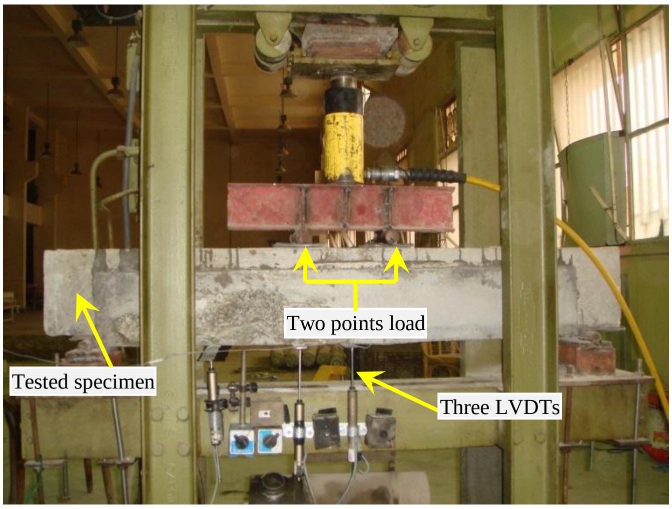

Fig. 8. Testing setup.

Fig. 9. Crack patterns of specimen B2 strengthened with external additional horizontal steel bars 2Ø8 with 2 vertical steel clamps.

VII. EXPERIMENTAL TEST RESULTS

a. Deflection and crack pattern of strengthened and retrofitted beams

Figure (10) shows the crack pattern for control, strengthened and retrofitted beams

Figure (11) shows the deflection along the beams jacketing strengthened by 3 plies steel wire mesh & external steel bars 2ø8 to 5ø8 fixed with 2 clamps.

Figure (12) shows the deflection line along the beams jacketing strengthened by 3 plies steel wire mesh & external steel bars 3ø8 fixed with 2 to 8 clamps.

Figure (13) shows the deflection line along the beams retrofitted by 3 plies steel wire mesh & external steel bars 3ø8 with 2 clamps with preloading (0.00% to 100% of failure load).

Fig. 10. Crack pattern for control, strengthened and retrofitted beams

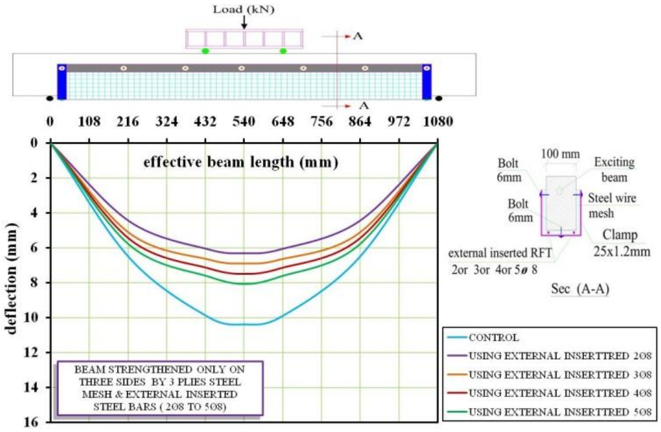

Fig. 11. Deflection along the beams strengthened by jacketing only on three sides by 3 plies steel wire mesh & external steel bars 2ø8 to 5ø8 fixed with 2 clamps

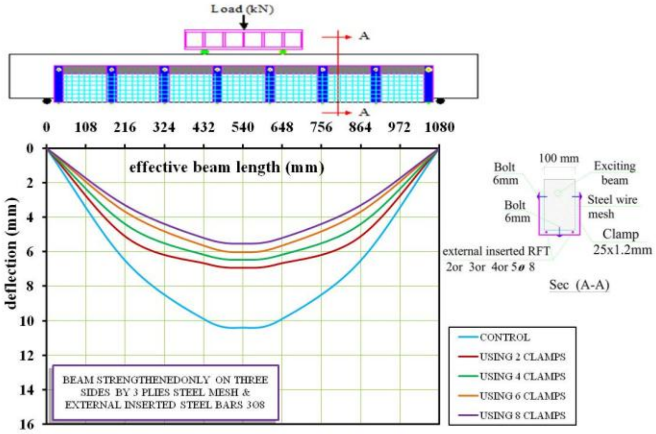

Fig. 12. Deflection along the beams strengthened only on three sides by 3 plies steel wire mesh jacketing & external steel bars 3ø8 fixed with 2 to 8 clamps

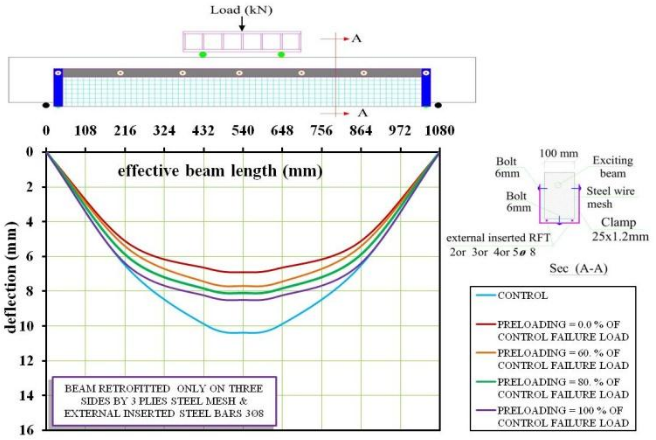

Fig. 13. Deflection along the beams retrofitted only on three sides by 3 plies steel wire mesh jacketing & external steel bars 3ø8 with preloading conditions (0.00%, 60.0%, 80.0% and 100.0% of failure load)

b. internal and external steel RFT strains

Figures (14) and (15) show the relationships between applied load and the longitudinal strain of the internal as well as external steel RFT for beams strengthened only on three sides by 3 plies steel wire mesh jacketing & external steel bars 2ø8 and 5ø8 fixed with 2 clamps.

Figures (16) and (17) show the relationships between applied load and the longitudinal strain of the internal as well as external steel RFT for beams strengthened only on three sides by 3 plies steel wire mesh jacketing & external steel bars 3ø8 fixed with 4 and 8 clamps.

Figures (18) and (19) show the relationships between applied load and the longitudinal strain of the internal as well as external steel RFT for beams strengthened only on three sides by 3 plies steel wire mesh jacketing & external steel bars 3ø8 fixed with 2 clamps with preloading conditions (0.00% and 100.0% of failure load).

Figures (20) and (21) show the relationships between applied load and the longitudinal strain of the internal and the external steel RFT respectively for the beams strengthened only on three sides by 3 plies steel wire mesh jacketing & external steel bars 2ø8 to 5ø8 fixed with 2 clamps.

Figures (22) and (23) show the relationships between applied load and the longitudinal strain of the internal and the external steel RFT respectively for beam strengthened only on three sides by 3 plies steel wire mesh jacketing & external steel bars 3ø8 fixed with 2 clamps with preloading conditions (0.00%, 60.0%, 80.0% and 100.0% of failure load).

Figures (24) and (25) show the relationships between applied load and the longitudinal strain of the internal and the external steel RFT respectively beam strengthened only on three sides by 3 plies steel wire mesh jacketing & external steel bars 3ø8 fixed with 2 to 8 clamps.

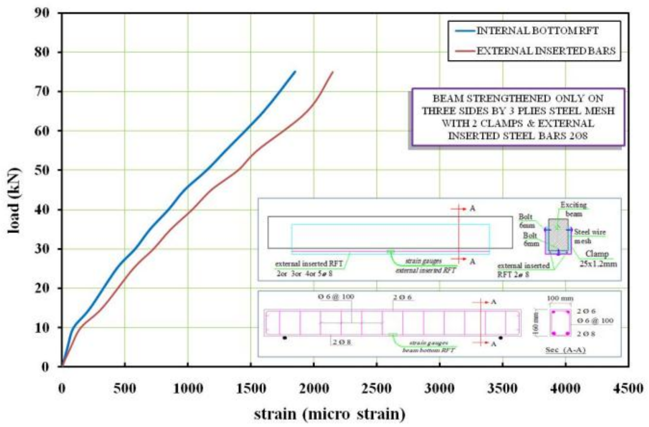

Fig. 14. Relationship between vertical applied load on the beam and the longitudinal strain of the internal and external steel bars for beam strengthened only on three sides by 3 plies steel wire mesh jacketing & external steel bars 2ø8

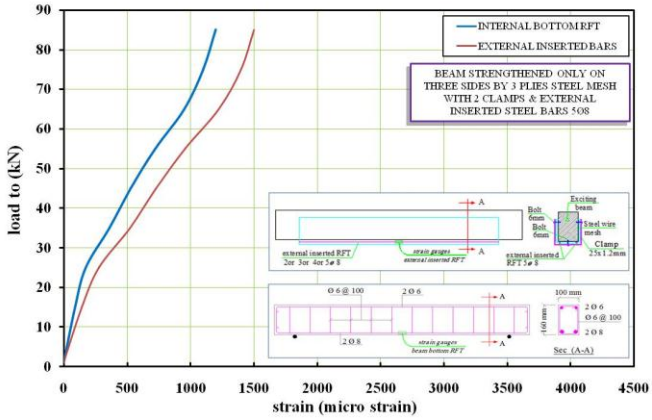

Fig. 15. Relationship between vertical applied load on the beam and the longitudinal strain of the internal and external steel bars for beam strengthened only on three sides by 3 plies steel wire mesh jacketing & external steel bars 5ø8

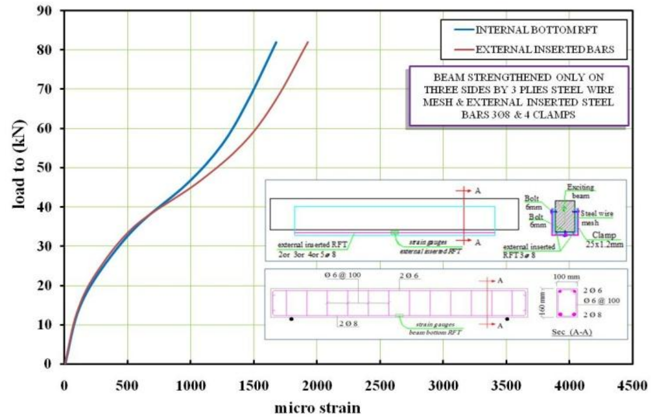

Fig. 16. Relationship between vertical applied load on the beam and the longitudinal strain of the internal and external steel bars for beam strengthened only on three sides by 3 plies steel wire mesh jacketing & external steel bars 3ø8 with 4 clamps

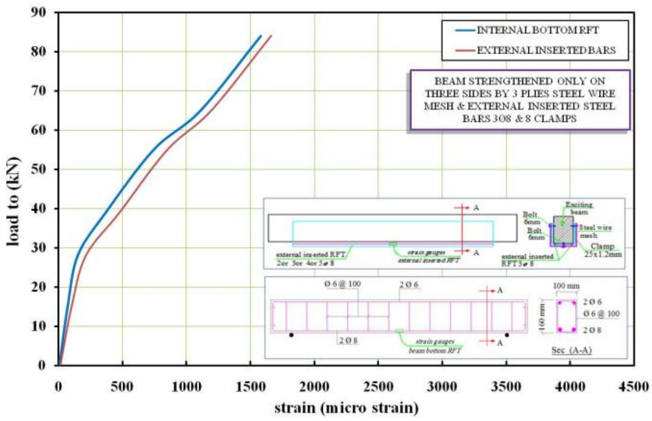

Fig. 17. Relationship between vertical applied load on the beam and the longitudinal strain of the internal and external steel bars for beam strengthened by on three sides by 3 plies steel wire mesh jacketing & external steel bars 3ø8 with 8 clamps

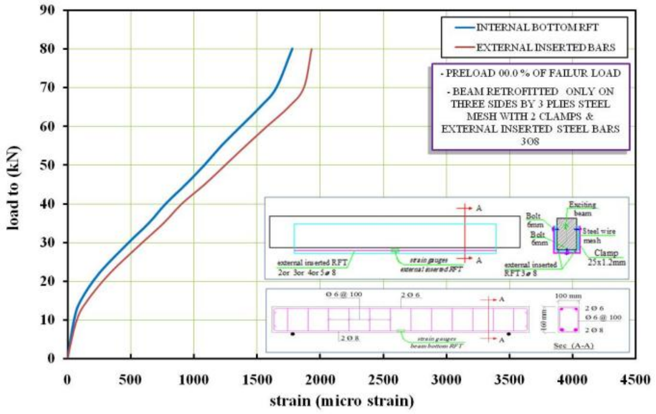

Fig. 18. Relationship between vertical applied load on the beam and the longitudinal strain of the internal and external steel bars for beam retrofitted only on three sides by 3 plies steel wire mesh jacketing & external steel bars 3ø8 with 2 clamps with preloading = 0.00 % of failure load

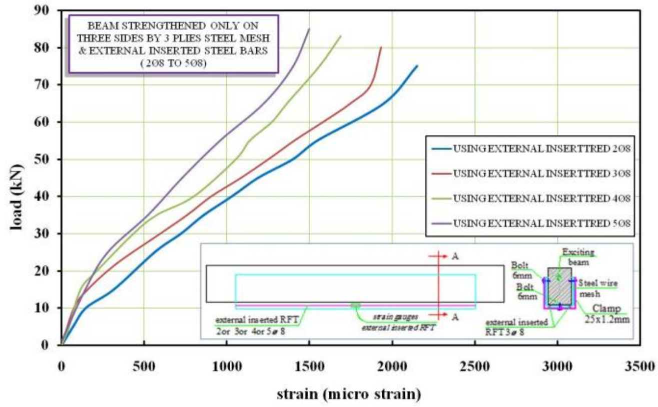

Fig. 21. Relationship between vertical applied load on the beam and the longitudinal strain of the external steel bars for beam strengthened only on three sides by 3 plies steel wire mesh jacketing & external steel bars 2ø8 to 5ø8

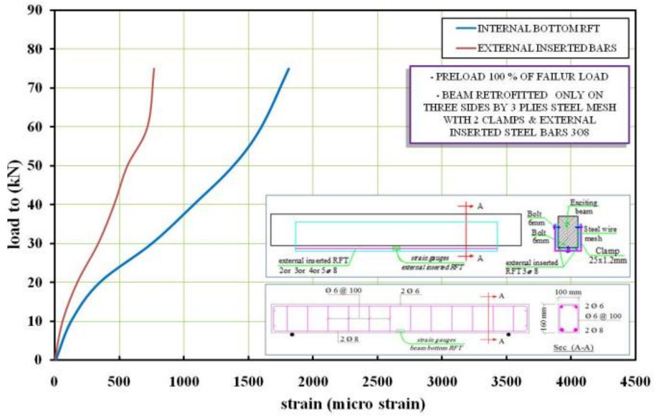

Fig. 19. Relationship between vertical applied load on the beam and the longitudinal strain of the internal and external steel bars for beam retrofitted only on three sides by 3 plies steel wire mesh jacketing & external steel bars 3ø8 with 2 clamps with preloading = 100.00 % of failure load

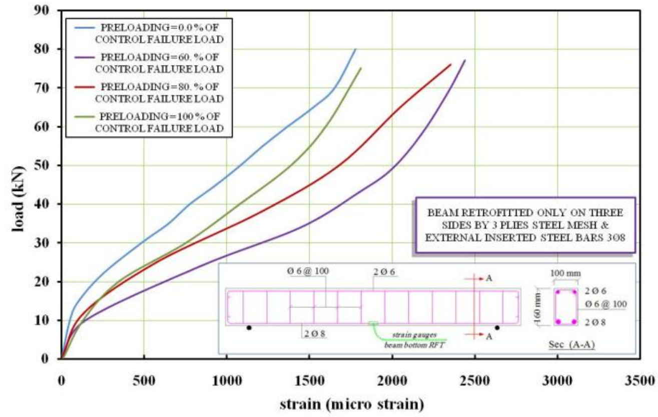

Fig. 22. Relationship between vertical applied load on the beam and the longitudinal strain of the internal steel bars for beam strengthened only on three sides by 3 plies steel wire mesh jacketing & external steel bars 3ø8 with 2 clamps with preloading from 0.00 % to 100 % of failure load

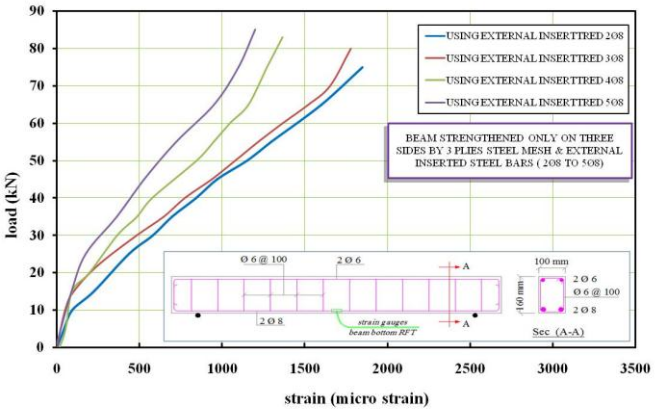

Fig. 20. Relationship between vertical applied load on the beam and the longitudinal strain of the internal steel bars for beam strengthened on three sides by 3 plies steel wire mesh jacketing & external steel bars 2ø8 to 5ø8

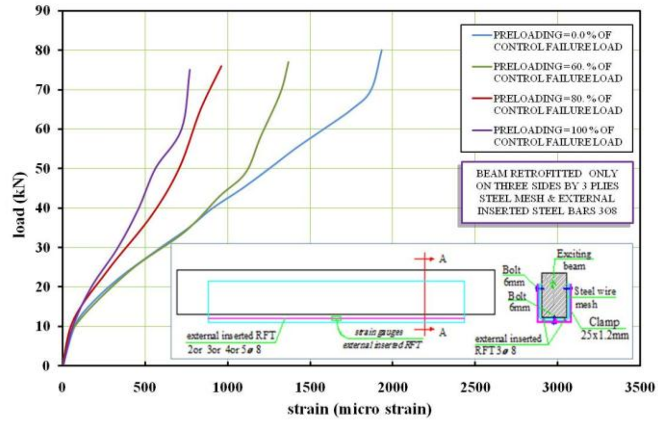

Fig. 23. Relationship between vertical applied load on the beam and the longitudinal strain of the external bars for beam retrofitted only on three sides by 3 plies steel wire mesh jacketing & external steel bars 3ø8 with 2 clamps with preloading from 0.00 % to 100 % of failure load

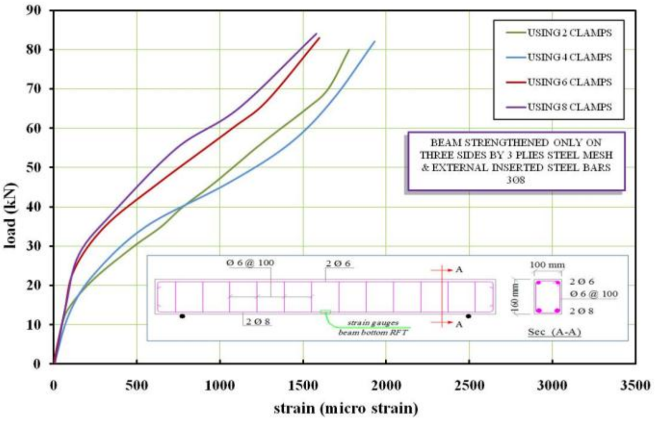

Fig. 24. Relationship between vertical applied load on the beam and the longitudinal strain of the internal steel bars for beam strengthened only on three sides by 3 plies steel wire mesh jacketing & external steel bars 3ø8 with 2 to 8 clamps

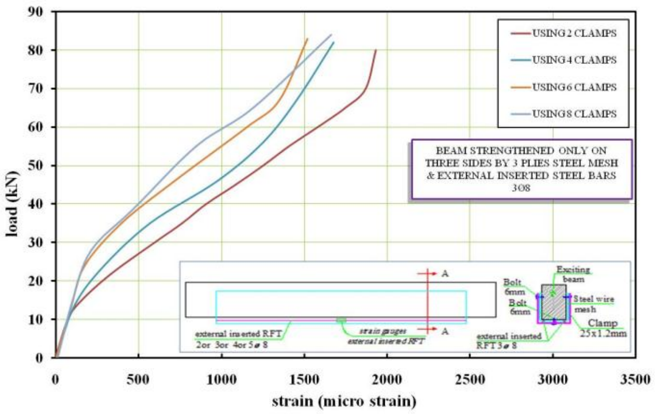

Fig. 25. Relationship between vertical applied load on the beam and the longitudinal strain of the external bars for beam strengthened only on three sides by 3 plies steel wire mesh jacketing & external steel bars 3ø8 with 2 to 8 clamps

c. Load carrying capacity for strengthened and retrofitted beams

Table (I) presents the failure loads and the percentages of increase in load carrying capacity for strengthened and retrofitted beams

Figure (26) shows the relationship between the increase in externally steel bars and the increasing in load carrying capacity for beams strengthened only on three sides by 3 plies steel wire mesh jacketing & external steel bars (2ø8 to 5ø8) fixed with 2 clamps.

Figure (27) shows the relationship between number of clamps and increasing in load carrying capacity for beams strengthened only on three sides by 3 plies steel wire mesh jacketing & external steel bars 3ø8 fixed with 2 clamps.

Figure (28) shows the relationship between the preloading conditions (0.0%, 60.0%, 80.0% and 100.0%) and the increasing in load carrying capacity for beams retrofitted only on three sides by 3 plies steel wire mesh jacketing & external steel bars 3ø8 fixed with 2 clamps.

Figure (29) shows the increase in load carrying capacity for all strengthened and retrofitted beams.

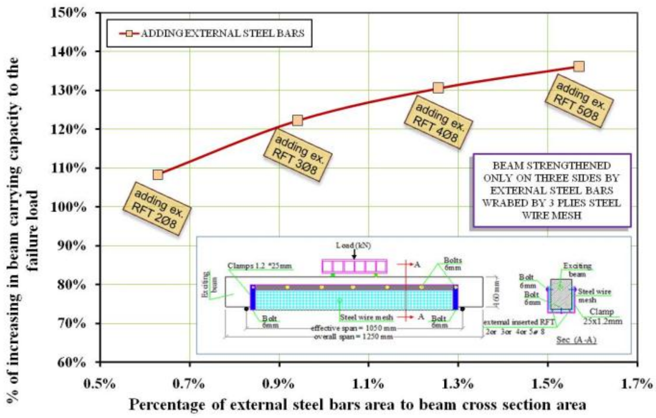

Fig. 26. The relationship between the number of external steel bars and the increasing in load carrying capacity for beams strengthened only on three sides by 3 plies steel wire mesh jacketing & external steel bars 2ø8 to 5ø8 with 2 clamps

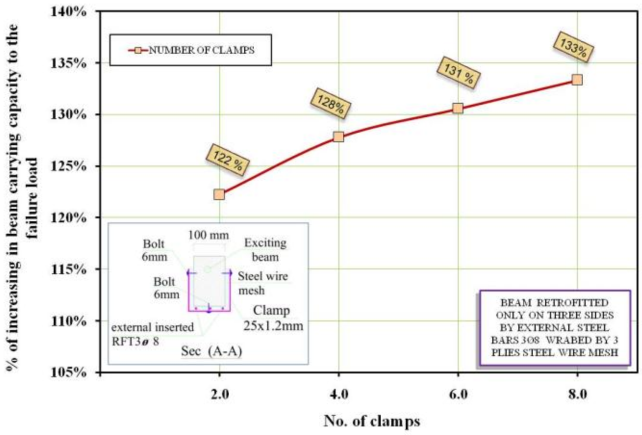

Fig. 27. The relationship between number of clamps and increasing in load carrying capacity for beams strengthened only on three sides by 3 plies steel wire mesh jacketing & external steel bars 3ø8 fixed with 2 clamps

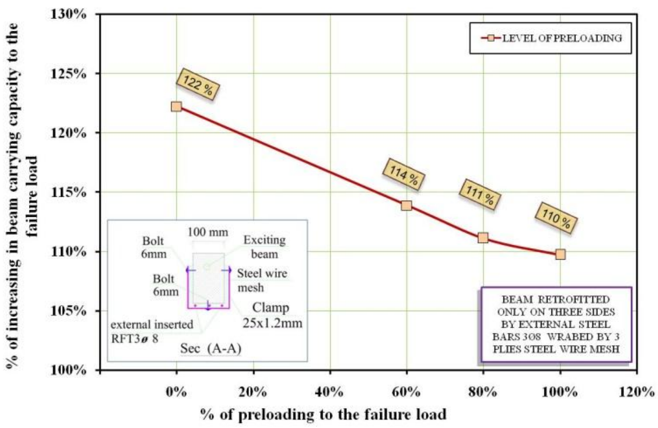

Fig. 28. The relationship between percentage of preloading of control failure load to the increasing in load carrying capacity for beams retrofitted only on three sides by 3 plies steel wire mesh jacketing & external steel bars 3ø8

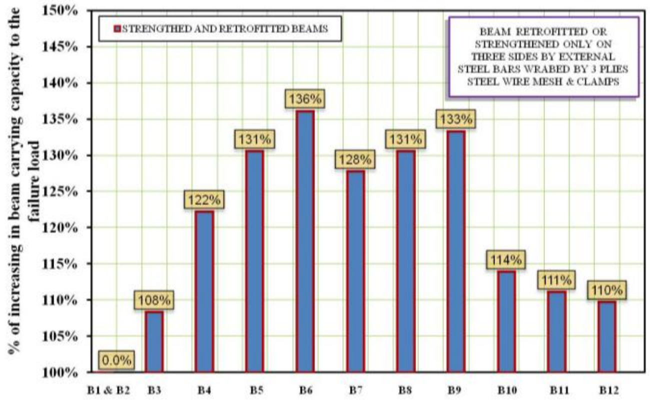

Fig. 29. The increase in load carrying capacity for all strengthened and retrofitted beams.

VIII. ADVANTAGES OF THE PROPOSED TECHNIQUE

- The proposed technique of strengthening the RC beams is easy and simple to install.
- The used technique is cheaper in cost compared to other techniques and can be constructed in a short period of time.
- This technique could be extended to continuous beams in which both positive and negative regions could be externally reinforced.

IX. CONCLUSIONS

From the present investigation, the followings are concluded:

- New jacketing technique is presented by wrapping RC beams with steel wire mesh with additional external steel bars.
- Results of longitudinal strain for the internal and external steel bars proved that the jacketing technique is really efficient and contribute in improving the beam performance.
- The presented strengthening technique can significantly increase the load carrying capacity, enhance the flexural and shearing strength as well as the performance of the RC beams.
- In the new jacketing technique, increasing the area of additional external steel bars increases load carrying capacity from 108% to 136% and decreases the vertical deflection along the beam.
- Increasing the number of vertical clamps slightly increases the ultimate load carrying capacity by (25%) and decreases the vertical deflection along the beam..
- Preloading of beams from 0.00 % to 100 % increases the ultimate load carrying capacity of the retrofitted beams from 122% to 108 %.

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