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Shear Behavior of Recycled Beams

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ABSTRACT: The present study will focus on the utilization of aggregates created mainly from crushing old concrete masses, the type of recycled aggregates that contains little or no impurities. Use of recycled aggregate in concrete can be useful for environmental protection and economy. Thus, use of recycled aggregates is an important and relevant area of research While the constant and variable angle truss models are known to provide reliable bases and to give reasonable predictions for the shear strengths of members with shear reinforcement, in the case of members without shear reinforcement, even advanced models with complicated procedures may show lack of accuracy or lead to fairly different predictions from other similar models. For this reason, many research efforts have been made for more accurate predictions. The dissertation compares the shear resistance of RAC based on the results of experimental investigation on 12 flexuraly reinforced beams without shear reinforcements with different models. Experimental investigations have been carried out to study shear strength of Recycled concrete beams having different shear span to depth ratio and having different percentage of longitudinal reinforcement.

I.INTRODUCTION

Recycled aggregates are aggregate resultant from the processing of inorganic material earlier used in construction, e.g. crushed concrete, masonry and brick. Recycled aggregates can be broadly subdivided into two main categories:

1. Aggregates derived predominantly from crushed concrete rubble which contains a maximum of 5% masonry.
2. Aggregates created from the extensive field of construction and demolition waste (C&DW) such as brick-based recycled aggregates and asphalt-based recycled aggregates that can contain up to 100% masonry.

The level of impurities in the second category (particularly those derived from asphalt pavements) is usually medium to high and can significantly affect the strength and performance when used in concrete. Use of recycled aggregate in concrete can be useful for environmental protection and economy. Thus, use of recycled aggregates is an important and relevant area of research.

The shear failure is brittle and sudden and these may come without any warning that is why shear failures are more catastrophic than the other failures. The modes of failure due to shear are Diagonal tension failure , Shear compression failure, Shear tension failure, Web crushing failure &Arch rib failure.

The shear transfers mechanisms help to identify the predictive parameters to facilitate affect the shear strength of a RC beam, such as: - compressive strength of concrete, effective depth of beam, shear span-to-depth ratio, quantity of longitudinal reinforcement& axial forces acting.

II.LITERATURE REVIEW

Xiao et al. (2012) tested 32 shear push-off specimens with different percentages of recycled coarse aggregate replacement. They report no important dissimilarity observed in terms of shear stress-slip curves, crack distribution path and shear transfer performance across cracks between the RAC and CC specimens. They also concluded that recycled aggregate replacement up to 30% did not affect ultimate shear load, but for higher percentages of RAC substitution, the ultimate shear load decrease.

Choi et al. (2010) concluded that the shear strength of the RAC beams was lower than that of the CC beams with the same reinforcement ratio and shear span-to-depth ratio. They reported that beams with smaller span-to-depth ratios and higher percentage of recycled aggregate showed a higher reduction in shear strength.

Hassan et al (2008), concluded that despite the reduction in the reinforcement ratio by 40%, the shear strength of concrete beams reinforced with high-strength steel was significantly higher than that of the beams reinforced with Grade 420 MPa (60 ksi) steel. The high yield strength of the material maintained the capacity of the tension tie, and thus enabled the beams to resist more load until crushing of the diagonal strut occurred. It was also found that the ACI 318-05 shear design provisions were un-conservative for large-size concrete beams without web reinforcement.

III.METHODOLOGY

3.1 PROPOSED EXPERIMENT

Twelve different combinations of beams have been to know in which combination the shear strength of the beam is more or it can be said that to know the affects of the characteristic strength of concrete and the shear span to depth ratio over the shear strength of the recycled concrete beam having constant reinforcement. The percentage steel has been selected to be 1% & 2% in all the beams irrespective of their compressive strength and a/d ratio. The 1% & 2% value for ρ_t has been decided so as to make the beams over-reinforced, and hence, ensure their moment capacity to be much higher than their shear capacity so that shear failure dominates in all cases. However, 2 bars of 12 mm each has to be provided in compression zone between the loading points (region of maximum bending moment for symmetric two-point loading system). The distance between load points has been fixed at 600 mm, 300 mm each from the mid span. The effective cover in all the beams has been made to be approximately 40 mm by arranging the reinforcement bars in two layers having a gap of 25 mm as per the provision of IS 456:2000 (i.e. the max. dia. of long. bar or max. aggregate size plus 5 mm whichever is less).

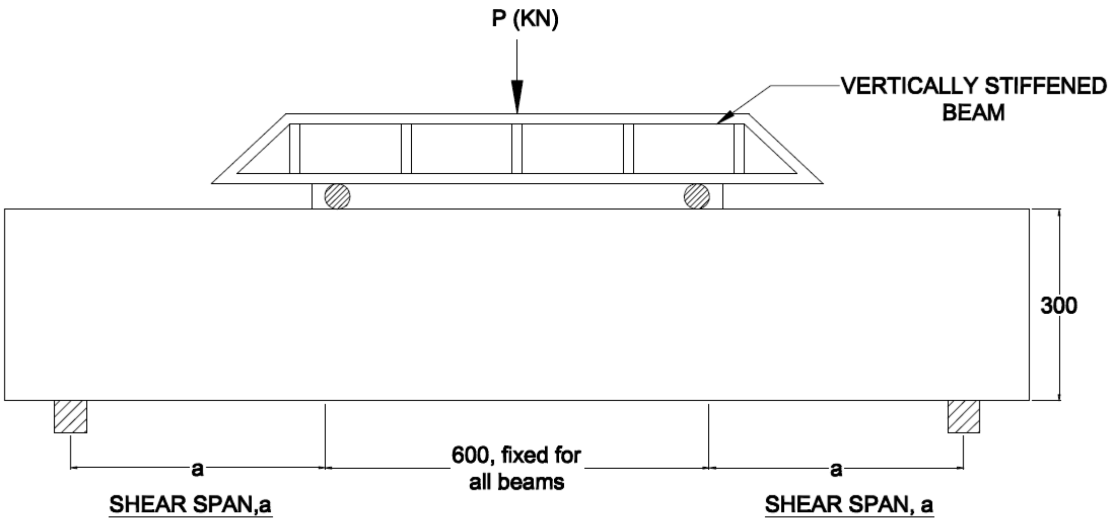

Fig1: Test set-up configuration

b = 150 mm for all beams, D = 300 mm, d = 265 mm

a/d = 1.5, 2.5 & 3.5 for all beams

ρ_t = 100 Ast/bd = 1% & 2% for all

beams

The parameters of study are the shear span-to-effective depth ratio and grades of concrete. Tests have been carried out on 12 beams, simply supported under two points loading spaced at a distance of 600 mm. All the beams have constant cross section of 150mm x 300mm. Detailed schedule of the beams has been given in table 2.

The usual arrangement for investigating shear failure is that of a beam subjected to symmetrically placed two equal concentrated loads 'P' at distance 'a' (shear span) from the supports. It has the advantage of combining two different test conditions, viz, pure bending, that is, no shear force is present between the two loads P, and constant shear force in the two end regions or shear spans.

Table 1: Quantities of materials for RCA Mix

Mix Type	**Binder (Kg/m^3)**	**Cement (Kg/m^3)**	**Fly Ash (Kg/m^3)**	**Water (Kg/m^3)**	**20 mm (Kg/m^3)**	**10mm (Kg/m^3)**	**Sand (Kg/m^3)**
P_20	480	384	96	136.27906	463.104	308.736	830.506
P_30	533	426.4	106.6	197.31286	463.104	308.736	836.043

Table 2: Detailed Schedule of Beams

Sr. No.	**Specimen Designation**	**Shear span-to-depth Ratio (a/d)**	**$\rho_t = 100A_{st}/bd$ (%age)**	**Overall Depth of Beam, (mm)**	**Effective Depth (d) (mm)**	**Nos. of Long. bars provided**	**Effective span (mm)**	**Overall length provided, L (mm)**
1	P1	1.5	1	150	117	4- 12 Ø	1356	1600
2	P2	2.5	1	150	117	4- 12 Ø	1830	2100

3	P3	3.5	1	150	117	4- 12 Ø	2364	2600
4	P4	1.5	2	150	117	7- 12 Ø	1356	1600
5	P5	2.5	2	150	117	7- 12 Ø	1830	2100
6	P6	3.5	2	150	117	7- 12 Ø	2364	2600
7	P1	1.5	1	150	117	4- 12 Ø	1356	1600
8	P2	2.5	1	150	117	4- 12 Ø	1830	2100
9	P3	3.5	1	150	117	4- 12 Ø	2364	2600
10	P4	1.5	2	150	117	7- 12 Ø	1356	1600
11	P5	2.5	2	150	117	7- 12 Ø	1830	2100
12	P6	3.5	2	150	117	7- 12 Ø	2364	2600

IV. RESULTS AND DISCUSSION

4.1. HARDENED CONCRETE TEST RESULTS

4.1.1. Compressive strength & Flexural Strength

In order to study the compressive strength & Flexural Strength of two different grades of recycled concrete mixes which are M-20 and M-30. The test has been conducted on ASTM of capacity 2000 KN.

Table 3: Compressive Strength & Flexural Strength

Mix	Mix Designation	Compressive Strength (in Mpa)	Flexural Strength (in Mpa)
		28 Days	**28 Days**
M-20	P1	22.67	7.20
	P2	19.41	7.56
	P3	17.42	7.81
	P4	25.67	8.02
	P5	28.40	8.10
	P6	27.46	7.31

M-30	P7	32.67	6.12
	P8	29.89	7.05
	P9	27.53	6.77
	P10	35.64	6.44
	P11	38.34	6.65
	P12	27.64	6.71

Table 4: Experimental Failure Load and Ultimate Shear Stress

Sr. No.	**Grade**	**Specimen Designation**	**ρ, (%)**	**(a/d) Ratio**	**Breadth of Beam,b(mm)**	**Eff. depth of beam,d(mm)**	**Exp. Failure Load V_{exp} (kN)**	**Ultimate Shear Stress.Vus=Vexp/ bd (Mpa)**
1	**M-20**	P1	1	1.5	150	265	220	5.53
2		P2	1	2.5	150	265	129	3.25
3		P3	1	3.5	150	265	78	1.96
4		P4	2	1.5	150	265	229	5.76
5		P5	2	2.5	150	265	137	3.45
6		P6	2	3.5	150	265	85	2.14
7	**M-30**	P7	1	1.5	150	265	226	5.69
8		P8	1	2.5	150	265	133	3.35
9		P9	1	3.5	150	265	81	2.04
10		P10	2	1.5	150	265	238	5.99
11		P11	2	2.5	150	265	144	3.62
12		P12	2	3.5	150	265	92	2.31

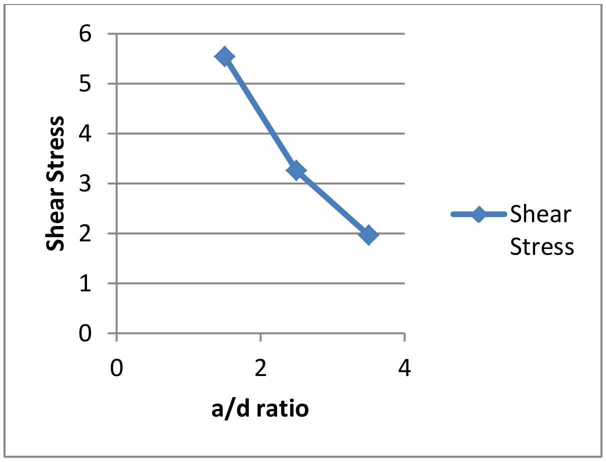

Fig2: Variation of ultimate shear stress with respect to a/d ratio for M-20 concrete having 1% longitudinal steel

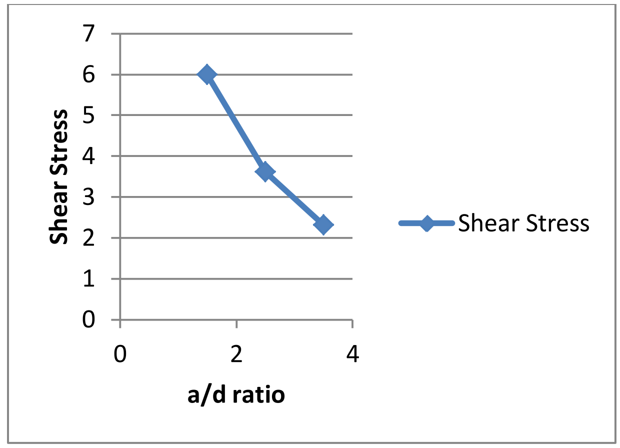

Fig4: Variation of ultimate shear stress with respect to a/d ratio for M-30 concrete having 1% longitudinal steel

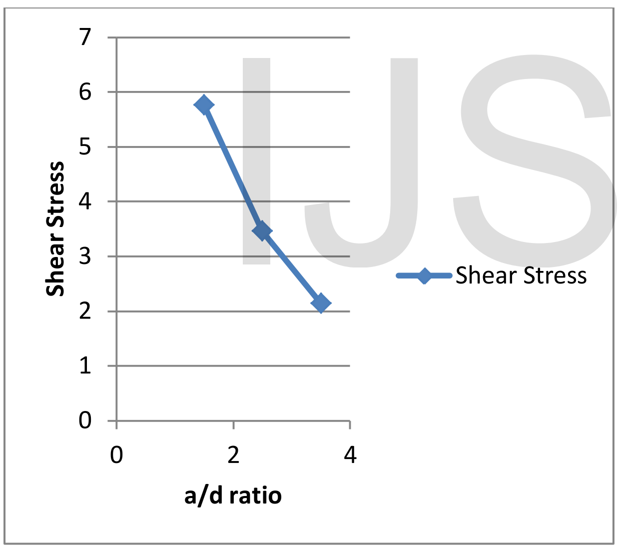

Fig3: Variation of ultimate shear stress with respect to a/d ratio for M-20 concrete having 2% longitudinal steel

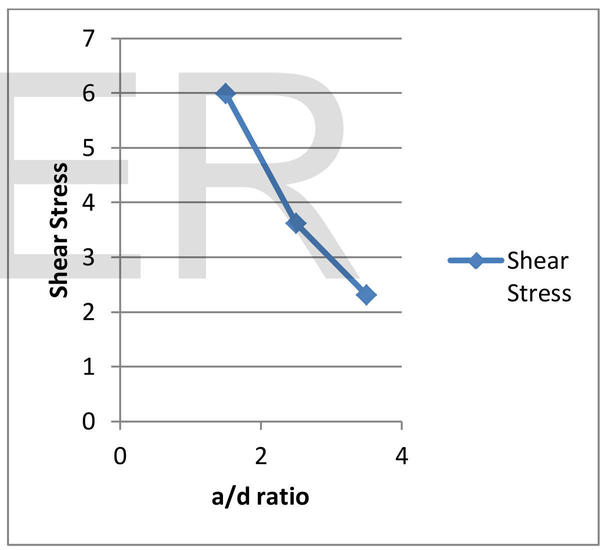

Fig5: Variation of ultimate shear stress with respect to a/d ratio for M-30 concrete having 2% longitudinal steel

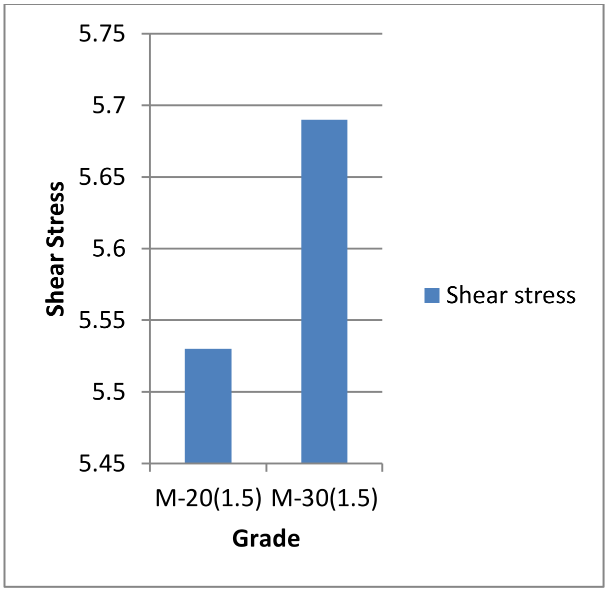

Fig5: Variation of ultimate shear stress with respect to grade of concrete having 1% longitudinal steel and a/d ratio of 1.5

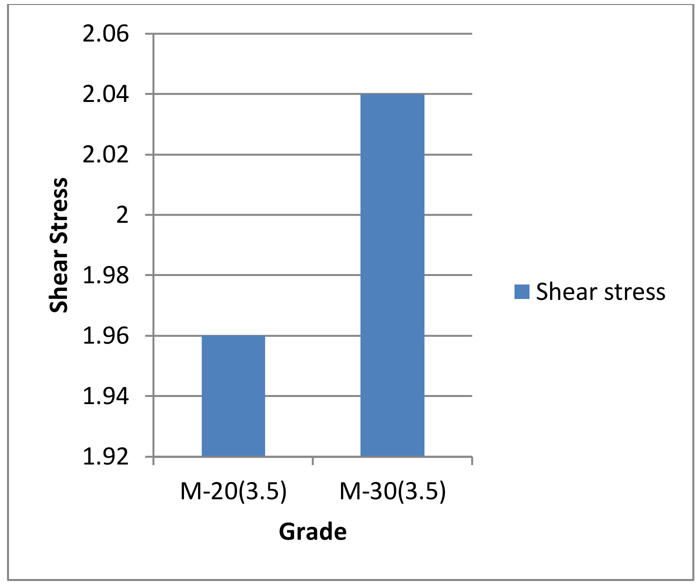

Fig7: Variation of ultimate shear stress with respect to grade of concrete having 1% longitudinal steel and a/d ratio of 3.5

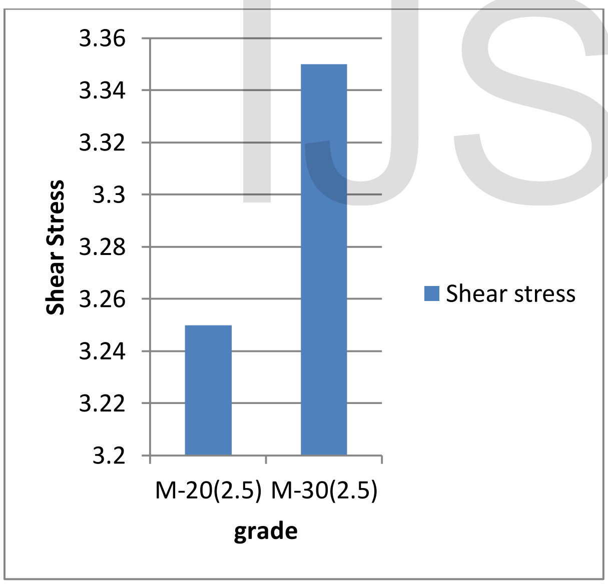

Fig6: Variation of ultimate shear stress with respect to grade of concrete having 1% longitudinal steel and a/d ratio of 2.5

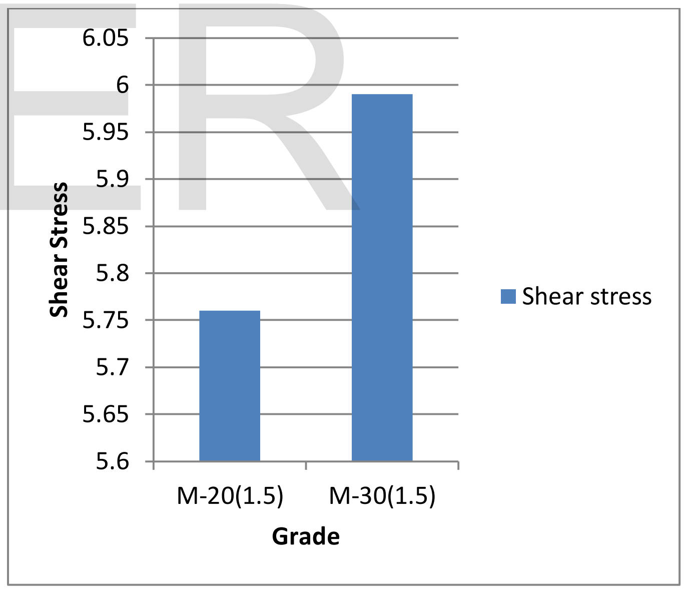

Fig8: Variation of ultimate shear stress with respect to grade of concrete having 2% longitudinal steel and a/d ratio of 1.5

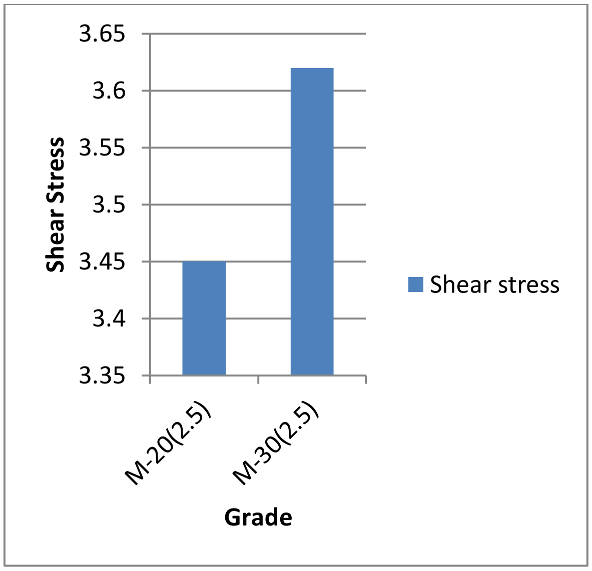

Fig9: Variation of ultimate shear stress with respect to grade of concrete having 2% longitudinal steel and a/d ratio of 2.5

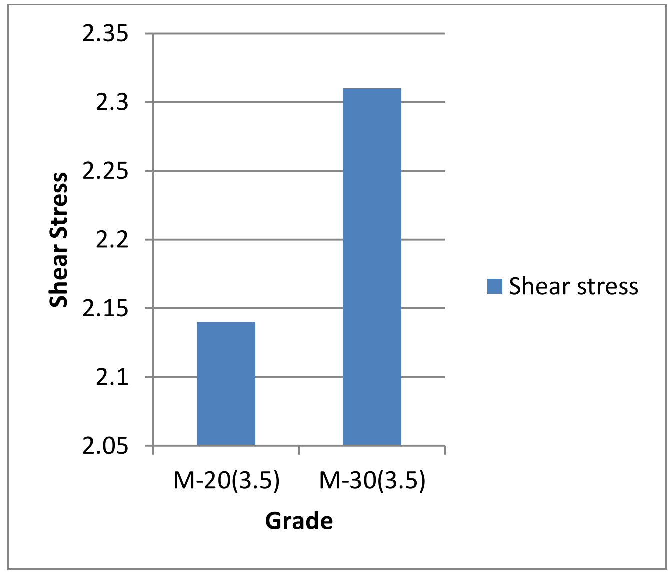

Fig10: Variation of ultimate shear stress with respect to grade of concrete having 2% longitudinal steel and a/d ratio of 3.5

V.CONCLUSIONS

5.1 CONCLUSIONS

Experimental study has been carried out to investigate the influence of span-to-depth ratio, percentage of longitudinal reinforcement and concrete grade on the shear strength of recycled concrete beams. The 3 different values of span to depth ratio has been taken 1.5, 2.5 and 3.5. 1% and 2% longitudinal reinforcement with M20 and M30 grade of concrete has been considered. The effective depth and width of beams have been kept constant. Following conclusions are drawn on the basis of limited experimental investigations:

1. For constant grade of concrete and constant percentage of steel as span to depth ratio increases, ultimate shear stress decreases.

   (a) For M-20 concrete having 1% longitudinal steel, when a/d ratio increases from 1.5 to 3.5, decrease in shear stress is

64.56%

(b) For M-20 concrete having 2% longitudinal steel, when a/d ratio increases from 1.5 to 3.5, decrease in shear stress is 62.85%

(c) For M-30 concrete having 1% longitudinal steel, when a/d ratio increases from 1.5 to 3.5, decrease in shear stress is 64.15%

(d) For M-20 concrete having 2% longitudinal steel, when a/d ratio increases from 1.5 to 3.5, decrease in shear stress is 61.43%

2. For constant a/d ratio and constant percentage of longitudinal steel, as grade of concrete increases from M-20 to M-30, shear stress increases

(a) - For a/d ratio of 1.5 and 1% long. Steel, increase is 2.81%

- For a/d ratio of 2.5 and 1% long. Steel, increase is 2.98%
- For a/d ratio of 3.5 and 1% long. Steel, increase is 3.92%

Average increase is 3.24%.

(b) - For a/d ratio of 1.5 and 2% long. Steel, increase is 3.84%

- For a/d ratio of 2.5 and 2% long. Steel, increase is 4.70%
- For a/d ratio of 3.5 and 2% long. Steel, increase is 7.36%

Average increase is 5.30%.

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