EXPERIMENTAL INVESTIGATION OF FLEXURAL BEHAVIOUR OF RCC BEAM EMBEDDED WITH PVC PIPE FILLED WITH WASTE CRUMBLED RUBBER POWDER

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PROJECT GUIDE

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ABSTRACT

- This project works is to investigate the flexural behaviour of concrete beams strengthened using rubber powder-filled via PVC pipe.
- One of the beams is used as a control beam (conventional beam) while the remaining beams were strengthened before testing to failure under flexural loading.
- The results may show that the rubber powder-filled beam weight may reduce and strength may increase because due to the rubber powder in the centre of the beam, the seismic load may withstand this due to the little deformation by the rubber powder.
- The ultimate and service load of the strengthened beams were increased. The strengthening of beams with rubber powder may enhance their stiffness.
- Modification factors for flexural strength beam may get strengthened using rubber powder may be proposed from this project works.

INTRODUCTION

- Cement and aggregate are the most important constituents used in concrete production and are the vital materials needed for the construction industry.
- To reduce the dumping of waste material, utilize them as raw materials in construction industry.
- Waste rubber from lorry tyre and bicycle tyre has received a great deal of attention for utilization because of its large production volume and difficulty of disposal.
- This rubber is grinded into fine size rubber crumbs and compacted inside the PVC pipe. and the rubber filled PVC pipe is placed inside the reinforcement concrete so that the neutral axis of the concrete touches the mid-point of the rubber filled PVC pipe.

LITERATURE REVIEW

MOSTAFA FAKHARIFAR A , GENDA CHEN,"**FRP-CONFINED CONCRETE FILLED PVC TUBES: A NEW DESIGN CONCEPT FOR DUCTILE COLUMN CONSTRUCTION IN SEISMIC REGIONS**'', CONSTRUCTION AND BUILDING MATERIALS(17 NOVEMBER 2018).

ABSTRACT	PARAMETER	RESULT
• This paper introduced and validated a new ductile design concept of confined concrete-filled polyvinyl-chloride tubular (CCFPT) columns through experimental and analytical studies the axial and flexural behavior of FRP confined concrete-filled PVC tubular columns and compares their performance with those of concrete-filled PVC tubular columns and FRP-wrapped columns. • Polyvinyl-chloride (PVC) tube and fibre-reinforced polymer (FRP) wrappings or FRP with a sandwiched layer of foam to enhance impact energy reduction due to potential FRP rupture and PVC fracture.	• Introduction of foam between FRP layers proved to be an effective method to lessen the brittleness, and obtainment of relatively ductile member's response upon FRP rupture. • Concrete filled PVC tube beams demonstrate ductile plastic response under flexure.'	• PVC tube contributed little to the axial strength of concrete columns, but FRP wraps with fiber oriented significantly strengthen the columns. • PVC tube fractured right after the rupture of its immediate FRP wraps resulting in a sudden loss of load carrying capacity. This brittle failure mode can be prevented by introducing an energy absorption foam layer between the PVC tube and the FRP wraps • PVC tube in CCFPT beams results in improved peak strength and initial stiffness

MINHAO DONGA , MOHAMED ELCHALAKANIA , ALI KARRECHA , MOSTAFA FAHMI HASSANEINB , TIANYU XIEC , BOYANG,"**BEHAVIOR AND DESIGN OF RUBBERISED CONCRETE FILLED STEEL TUBES UNDER COMBINED LOADING CONDITIONS**",THIN-WALLED STRUCTURES(21 FEBRUARY 2019).

ABSTRACT	PARAMETER	RESULT
• This paper explored the option to effectively confine the rubberized concrete with steel tubes to obtain enhanced strength and ductility. The behavior and performances of thirty rubberized concrete-filled single-skin steel tubes(CFST) of various rubber content, steel section and load eccentricities was systematically investigated in this study	• The 15% rubber replacement ratio showed a good balance of strength and ductility.	• The results have shown that confined rubberized concrete and the restrained steel tube improved ductility of the composite section. • The rubberized concrete was more effective in delaying the premature buckling failure of the steel tube compared to the more brittle normal cement concrete. • It is recommended to confine RuC with steel tubular sections in the future construction as flexible roadside barriers, and beams and columns in buildings in seismic active zones

MD. SHAHJALAL A , KAMRUL ISLAM A, B , JESIKA RAHMAN A, D , KHONDAKER SAKIL AHMED A , MOHAMMAD REZAUL KARIM C , AHM MUNTASIR BILLAH D,"**FLEXURAL RESPONSE OF FIBER REINFORCED CONCRETE BEAMS WITH WASTE TIRES RUBBER AND RECYCLED AGGREGATE**",JOURNAL OF CLEANER PRODUCTION (26 AUGUST 2020).

ABSTRACT	PARAMETER	RESULT
• This deals with both different structural and non-structural applications. The use of RCA and CR as replacements of natural aggregates will contribute to the production of a sustainable material and cleaner environment. crumb rubber (CR) derived from the waste tire and recycled coarse aggregate (RCA) in concrete production pertains to a sustainable future of the construction industry • Concrete beams with 30% RCA, 5% CR and 0.5% PP(Polypropylene fiber) showed improved flexural capacity, ductility, and toughness.	• This study provides a comprehensive evaluation of a sustainable concrete made with RCA, CR, and PP fiber through large scale tests on reinforced FRC beams.	• The usefulness of RCA and CR in lieu of the natural aggregates in structural concrete elements is a noteworthy attempt in protecting the ecosystem • The splitting tensile strength is improved as PP fiber is added, The ultimate bending moment capacity are found to be 1.5 times • Both toughness and ductility values are found to be increased for CR

AHMED S. EISA, MOHAMED T. ELSHAZLI, MAHMOUD T. NAWAR,”**EXPERIMENTAL INVESTIGATION ON THE EFFECT OF USING CRUMB RUBBER AND STEEL FIBERS ON THE STRUCTURAL BEHAVIOR OF REINFORCED CONCRETE BEAMS**”, CONSTRUCTION AND BUILDING MATERIALS (5 APRIL 2020)

ABSTRACT	PARAMETER	RESULT
• This journal shows the investigation for crumb rubber replacement for aggregate. concrete mixtures may differ with changes in materials characteristics, mixture proportions of the ingredients, curing procedure, and use of admixtures and additives.	• Experimentally study the effect of crumb rubber and steel fibers on RC beams. • Incorporating 10%, rubber improved ductility and toughness of concrete mixtures. • Combining 1% steel fibers and 10%, rubber improved the performance of RC beams.	• Adding of steel fibers in concrete increases the compressive strength by 11–34%, the splitting tensile strength by 96–75%, and the modulus of rupture by 26–14%, when the percentage of crumb rubber vary from 0% to 20%, respectively. • Using crumb rubber as partial replacement of fine aggregates by 5% and 10% show good mechanical properties with increase in the toughness by 6% and 5%, and increase in the performance of rubberized reinforced concrete beams having rubber percentages over than 10%.

TRILOK GUPTA A , SALMAN SIDDIQUE B , RAVI K. SHARMA A , SANDEEP CHAUDHARY C,"**BEHAVIOR OF WASTE RUBBER POWDER AND HYBRID RUBBER CONCRETE IN AGGRESSIVE ENVIRONMENT**", CONSTRUCTION AND BUILDING MATERIALS (16 MAY 2019).

ABSTRACT	PARAMETER	RESULT
• The durability of waste rubber powder and hybrid (rubber powder and rubber fibers) concrete was observed. • It showed good resistance against acid attack and chloride ion diffusion. • acid and chloride resistance characteristics of rubber aggregate concrete make it suitable for application in chemical industrial flooring and sewage pipes	• Waste rubber aggregates in fiber and powder were used in concrete. • Durability properties against aggressive environment were evaluated. • Improved resistance to acid and chloride attack was observed on inclusion of waste rubber aggregate.	• The incorporation of rubber aggregate results in an increased probability of corrosion in concrete. The enhanced durability against chloride ion does not ensure durability against corrosion in case of rubber aggregate. The improper bond between rubber aggregate and cement paste leads to oxygen inflow which triggers corrosion in rebar. • The incorporation of rubber aggregate in concrete resulted in improved resistance to mass loss under acid attack as the hydrophobic nature of rubber delayed the penetration of the acidic solution into the concrete matrix

MOHAMED THAMEEM ANSARI, N. SAKTHIESWARAN, O. GANESH BABU,"MATERIALS TODAY: PROCEEDINGS,"**EXPERIMENTAL STUDY OF AN ECO-FRIENDLY CONCRETE BY INBUILT WITH TREATED CRUMB RUBBER",** MATERIALS TODAY: PROCEEDINGS(13 JUNE 2020).

ABSTRACT	PARAMETER	RESULT
• This deals with the surface treatment process and was proposed to make solid polarity groups to rubber surface to generate a solid chemical strength among the rubber and the concrete matrix. • It is an effective process to enhance the mechanical properties of concrete	• Treatment reduces the segregation made the rubber to be hydrophilic and increase the adhesive strength in the concrete. • The Hydro chloride acid attack test conducted on the specimens.	• Over all the replacement, 2.5 percentages are efficient and effective mix, for all the three tests it gives desirable strength. • the result of strength at 5% replacement gives higher strength 90% Compressive strength attains in 2.5% & 5% • Exactly 100% Flexural strength attains in 2.5% replacement of Treated Crumb Rubber by comparing with Control Mix.

CLAUDIO DE SOUZA KAZMIERCZAK A, SAMUEL DUTRA SCHNEIDER A , ORLANDO AGUILERA A , CRISTHIANA CARINE ALBERT A , MAURÍCIO MANCIO,"**RENDERING MORTARS WITH CRUMB RUBBER: MECHANICAL STRENGTH, THERMAL AND FIRE PROPERTIES AND DURABILITY BEHAVIOR",** CONSTRUCTION AND BUILDING MATERIALS (4 APRIL 2020).

ABSTRACT	PARAMETER	RESULT
• The difficulties related to waste tire disposal encourage the use of crumb rubber in civil construction as a component of cement composites. In this study, crumb rubber is evaluated as a partial replacement of the aggregate in rendering mortars , in quantities of 0%, 2%, 4% and 6%, using a systemic approach. • The physical and mechanical properties of the fresh and hardened mortars, thermal and fire properties and durability behavior are found.	• Mortars with 6% crumb rubber are non-combustible and do not propagate flames. • The increase of rubber content decreases the thermal conductivity of the mortar. • Rubber mortars cracking after thermal accelerated aging is lower than the reference • Use of crumb rubber in rendering mortars maintains the adhesion to ceramic substrate	• At fresh state, crumb rubber mortars require a higher water content to achieve the same workability of the control mixture, decrease the bulk density and increase the water retention and air content of the mortar. • The rendering mortars with 2% and 4% of crumb rubber content presented the best set of properties related to deformation capacity, thermal insulation and lower cracking, with tensile bond strength above the minimum required at standards.

SUMMERY OF THE LITERATURE:

- PVC tube in CCFPT(confined concrete-filled polyvinyl-chloride tubular) beams results in improved peak strength and initial stiffness.
- Rubberized concrete-filled single-skin steel tubes(CFST) results have shown that improved ductility, delaying the premature buckling failure and it can be used in beams and columns in buildings in seismic active zones.
- Concrete beams with 30% RCA, 5% CR and 0.5% PP(Polypropylene fiber) showed improved flexural capacity, ductility, and toughness
- Crumb Rubber replacement for aggregate- Incorporating 10%, rubber improved ductility and toughness of concrete mixtures. Combining 1% steel fibers and 10%, rubber improved the performance of RC beams.
- The durability of waste rubber powder and hybrid (rubber powder and rubber fibers) concrete was observed. resulted in improved resistance to mass loss under acid attack as the hydrophobic nature of rubber delayed the penetration of proposed a solid chemical strength among the rubber and the concrete matrix. 2.5 percentages are efficient and effective mix which gives desirable strength.
- waste tire disposal encourage the use of crumb rubber The acidic solution into the concrete matrix.the surface treatment process and was rendering mortars with 2% and 4% of crumb rubber content presented the best set of properties related to deformation capacity, thermal insulation and lower cracking, with tensile bond strength above the minimum required at standards.

PROBLEM STATEMENT:

- When rubbers crumbs are directly mixed with concrete and casted, its leads to poor bondage between rubber and cement causing voids.
- These voids tends to initiate corrosion in steel resulting in early crack formation than conventional concrete.
- To overcome these issues, this project introduces PVC compacted with rubber crumb there by avoiding direct contact with concrete and also increase the ductility behaviour.

AIM

- To investigate the flexural behaviour of the beam, which has Rubber crumbs compacted PVC pipe.
- Comparing flexural strength of the conventional beam to the proposed beam.

OBJECTIVES

- Performance evaluation of beam with PVC filled with rubber crumbs.
- To minimize the overall environmental effects by incorporate waste chipped rubber to the concrete.
- To study the flexural strength development of concrete with and without PVC pipe filled with rubber crumbs.

METHODOLOGY

Identify and selection of project area

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Literature survey

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Material Procurement

↓

Testing of raw material

↓

Mix Design

↓

Casting of Beams

↓

Testing & Comparison

↓

Results & Conclusion

MATERIAL TESTING:

1. CEMENT

Standard Consistency of Cement = (Quantity of water for 5-7 mm penetration/Weight of cement) X 100

TRIAL	Quantity of cement taken in g	Quantity of water added in ml	Penetration in mm	Nominal Consistency in %
1.	250	62.5	32	25
2.	250	75	11	30
3.	250	87.5	6	35
Average				30%

SETTING TIME OF CEMENT

Time at which water is added to cement (min)	Time at which the needle fails to pierce the test block by 5.0±0.5mm (min)	Initial setting time (min)
0	45	45

Time at which water is added to cement (min)	Time at which the needle fails to pierce the test block by 5.0±0.5mm (min)	Final setting time (min)
45	310	310

DETERMINATION OF SPECIFIC GRAVITY OF CEMENT

OBSERVATION:

1. Initial reading of flask in ml (V_1) : 0.5ml
2. Final reading of flask in ml (V_2) : 19.5ml
3. Volume of cement particle (V_2 - V_1) : 19ml
4. Weight of equal volume of water in g (W_2): 19ml
5. Specific gravity of cement (W_1/ W_2) : 3.15

CEMENT TESTING PHOTOS

FINENESS OF CEMENT

CONSISTENCY OF CEMENT

SETTING TIME OF CEMENT

SPECIFIC GRAVITY OF CEMENT

SIEVE ANALYSIS OF FINE AGGREGATE

Weight of fine aggregate taken (W_f): 500g					
Sl. No.	**Sieve size**	**Weight retained(in g)**	**%age retained** $\frac{C3}{W_f}$ x100	**Cumulative %age retained**	**Percentage passed (100 –C_5)**
C_1	C_2	C_3	C4	C_5	C_6
1	4.75 mm	9.4	1.88	1.88	98.12
2	2.36 mm	10.32	2.06	3.94	96.06
3	1.18 mm	30.78	6.16	10.1	89.9
4	600 micron	120.94	24.19	34.29	65.71
5	300 micron	134.12	26.82	61.11	38.89
6	150 micron	106.53	21.31	82.42	17.58
7	Pan	82.01	16.40	98.82	1.18
Fineness Modulus $\frac{\sum C5}{100}$ =				**2.93**	-
Zone to which the fine aggregate belongs:				**ZONE - II**	

SPECIFIC GRAVITY OF FINE AGGREGATE

Sl.no	Description(gm)	Trial1	Trial2	Trial3	Mean
1	Weight of empty bottle (M1)	612	612	612	2.75
2	Weight of bottle + Fine Aggregate(M2)	860	862	849	
3	Weight of bottle + Fine Aggregate + water (M3)	1608	1611	1611	
4	Weight of bottle + water (M4)	1450	1450	1450	
5	Specific gravity of Fine Aggregate	2.75	2.81	2.68	

FINE AGGREGATE TESTING PHOTOS

SIEVE ANALYSIS

SPECIFIC GRAVITY

SIEVE ANALYSIS OF COARSE AGGREGATE

Weight of coarse aggregate taken (W_c): 5Kg

Sl. No.	Sieve size	Weight retained (in kg)	%age retained $\frac{C3}{W_c} \times 100$	Cumulative %age retained	Percentage passed $(100 - C_5)$
C_1	C_2	C_3	C4	C_5	C_6
1	80 mm	0	0	0	100
2	40 mm	0	0	0	100
3	20 mm	4.755	95.1	95.1	4.9
4	10 mm	0.24	4.8	99.9	0.1
5	4.75 mm	0.004	0.08	99.98	0.02
6	Pan	0.001	0.02	100	-
Sum of cumulative percentage retained (excluding pan) $\sum C_5$=				494.98	-
Fineness Modulus $\frac{\sum C5}{100}$ +				4.95	-
Grade to which the coarse aggregate belongs:				Well Graded	

WATER ABSORPTION TEST

Water absorption = [(A – B)/B] x 100%.

TRIAL	Wt. of Saturated Sample in grams A	Wt. of Oven Dried Sample in grams B	%age of water absorption	Average
1.	1080	1010.2	6.91	4.04
2.	1072.9	1054.6	1.73	
3.	1036.4	1001.5	3.48	

IMPACT TEST OF COARSE AGGREGATE

S. NO	DESCRIPTION	TRIAL 1	TRIAL 2	TRIAL 3
1.	Total weight of aggregate sample filling the cylinder (W_1 g)	382	385	381
2.	Weight of aggregate passing 2.36mm sieve after the test (W_2 g)	79.6	74.3	82.7
3.	Aggregate Impact Value $(w_2/w_1) \times 100\%$	20.83	19.30	21.7
4.	Average Impact Value%	20.61		

Determination of Water Quality

S. NO	TESTS TO BE CONDUCTED	OBTAINED LIMITS	PERMISSIBLE LIMITS	REFERRED CODE BOOKS
1.	Determination of Calcium in the given water sample	72.156 mg/l	75mg/l	IS3025 (PART 23)
2.	Determination of Ammonia Nitrogen in the given water sample	11.3 mg/l	12mg/l	IS10500
3.	Determination of Chloride in the given water sample	200mg/l	250mg/l	IS3025 (PART 32)
4.	Determination of pH in the given water sample	7	6.5 – 8.5	IS3025 (PART 11)

MIX DESIGN

Grade Designation	M30
Type of cement	OPC 53grade
Fine Aggregate	Zone - II
Sp. Gravity Cement	3.15
Sp. Gravity Fine Aggregate	2.65
Sp. Gravity Coarse Aggregate	2.67
Sp. Gravity GGBS	2.84
Slump	100 mm

1. TARGET MEAN STRENGTH:

$f_{ck} = f_{ck} + 1.65s$

$= 30 + (1.65 \times 5)$

$= 38.25\ N/mm^2$

2. SELECTION OF WATER CEMENT RATIO:

W/c = 0.45 (From Table 5 of IS 456 – 2000)

Water cement ratio = 0.40 (Based on experience)

Adopt lower value   w/c = 0.40

3. CALCULATE OF WATER CONTENT & SAND CONTENT:

Water content = 186 kg (As per Table No. 2, IS: 10262:1982)

Required water content = $186+[\frac{6}{100} \times 186]$

$= 197.16 \text{ lit/ m}^3 \sim 197 \text{ lit/ m}^3$

Use of super plasticiser water content can reduced to 20%

$= 197\times0.8\sim158 \text{ lit/ m}^3$

4. CALCULATE THE CEMENT CONTENT:

Cement content = water content / w/c ratio

= 158/0.40

$= 395 \text{ kg/m}^3$

5. CALCULATE VOLUME OF CA &FA:

From Table 3 of is 10262 : 2009,

At rate of ±0.01 for every ±0.05 change in water-cement ratio

Therefore, Volume of coarse aggregate = 0.64

Volume of fine aggregate = 1 – 0.64 = 0.36

6. MIX CALCUALATION:

a. Volume of concrete = 1m^3

b. Volume of cement $= \frac{Mass\ of\ cement}{Specific\ Gravity\ of\ cement} \times \frac{1}{1000}$

$= \frac{395}{3.15} \times \frac{1}{1000}$

= 0.125m^3

c. Volume of water $= \frac{Mass\ of\ water}{Specific\ Gravity\ of\ water} \times \frac{1}{1000}$

$= \frac{158}{1} \times \frac{1}{1000}$ = 0.158 m^3

d. Volume of chemical admixture = $\frac{Mass\ of\ water}{Specific\ Gravity\ of\ water} \times \frac{1}{1000}$

(2% of cement) $= \frac{8}{2.84} \times \frac{1}{1000} = 0.002\ m^3$

e. Volume of all in aggregate = [a - (b+c+d)]

= [1 – (0.125+0.158+0.002)]

= 0.697 m^3

f. Mass of coarse aggregate = d × volume of C.A × specific gravity of C.A × 1000

= 0.697 × 0.64 × 2.67 × 1000

~1191 kg

g. Mass of fine aggregate = d × volume of C.A × specific gravity of F.A × 1000

= 0.697 × 0.36 × 2.65 × 1000

= 664.8~ 665 kg

7. RESULT:

a. Cement = 395 kg/m^3

b. Water = 158 litres

c. F.A = 665 kg

d. C.A = 1191kg

e. w/c ratio = 0.40

f. Chemical Admixture = 8kg

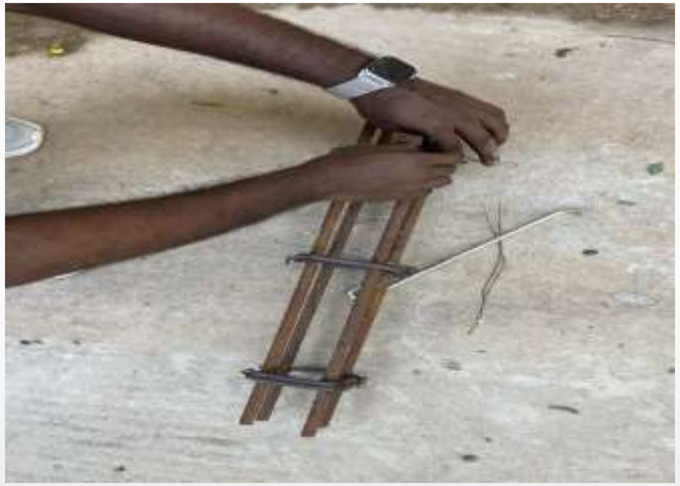
g. Mix Proportion =395: 665 : 1191

= 1: 1.68: 3.01

˜ 1: 1.5: 3

EXPERIMENTAL WORK

BEAM CASTING PHOTOS

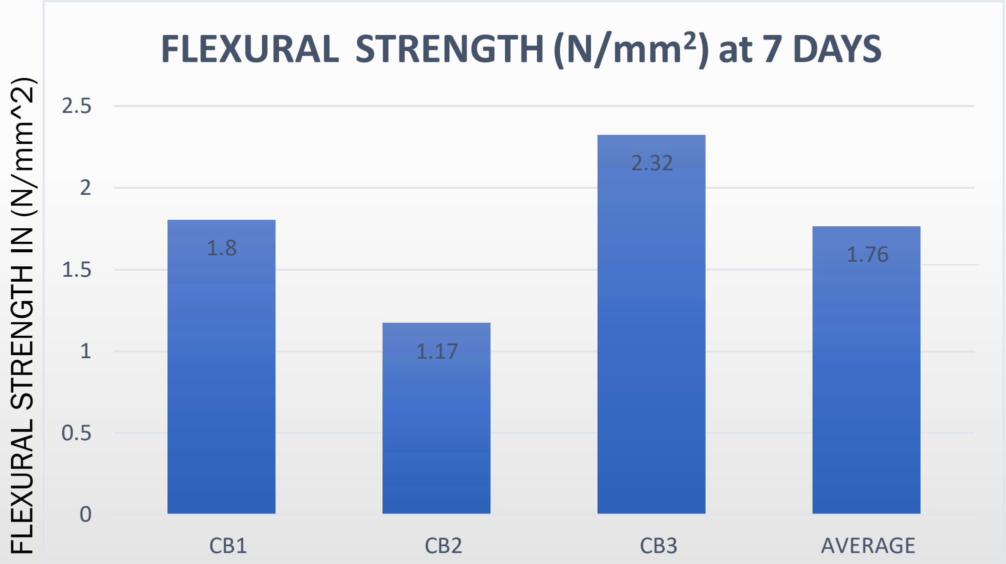


TESTING FOR FLEXURAL STRENGTH

TESTING PHOTOS

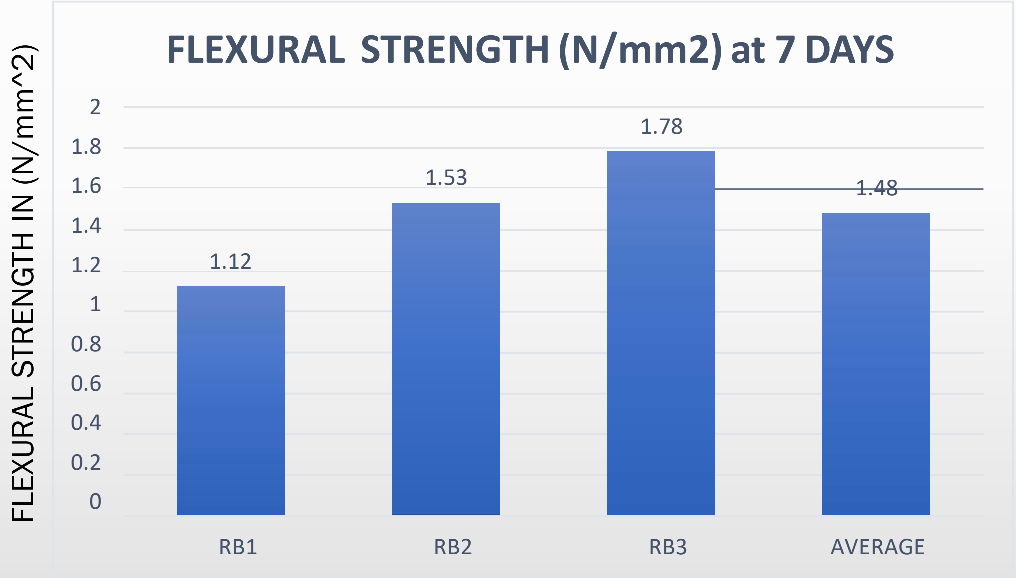
FLEXURAL STRENGTH OF CB AT 7 DAYS

SPECIMEN DETAILS	FLEXURAL STRENGTH (N/mm^2) at 7 DAYS
CB1	1.8
CB2	1.17
CB3	2.32
AVERAGE	1.76

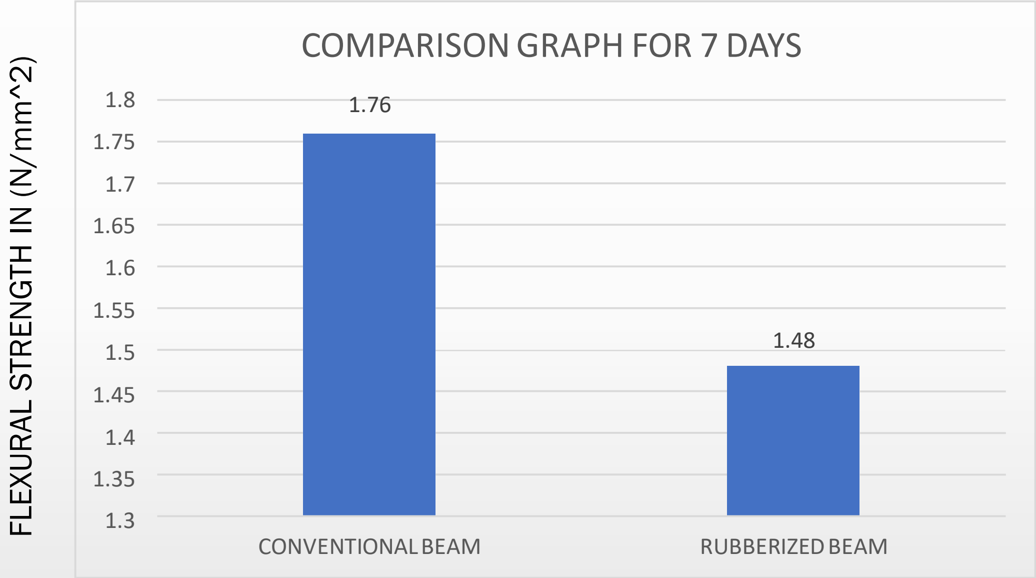


FLEXURAL STRENGTH OF RB AT 7 DAYS

SPECIMEN DETAILS	FLEXURAL STRENGTH (N/mm^2) at 7 DAYS
RB1	1.12
RB2	1.53
RB3	1.78
AVERAGE	1.48

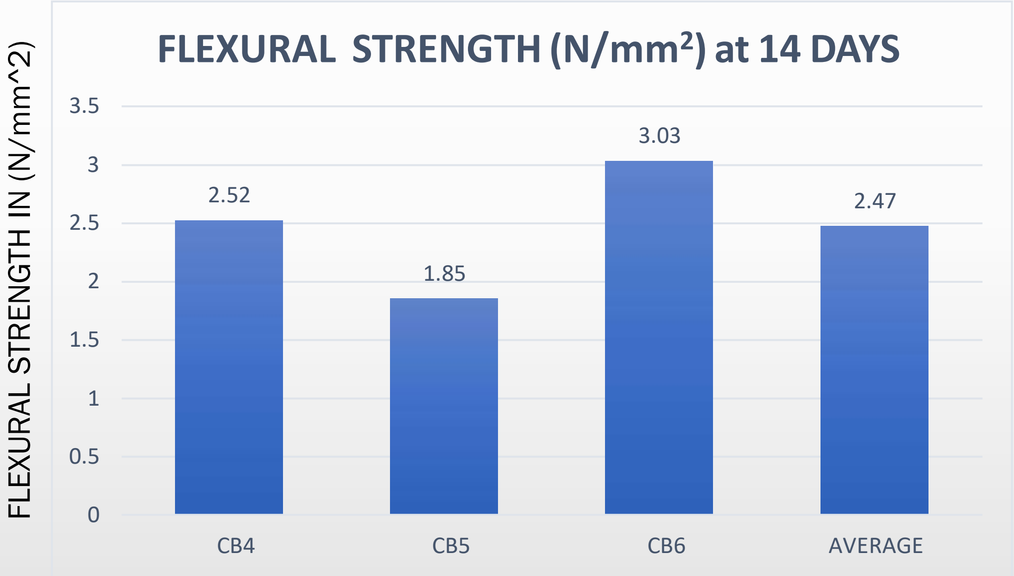


FLEXURAL STRENGTH OF CB VS RB AT 7 DAYS



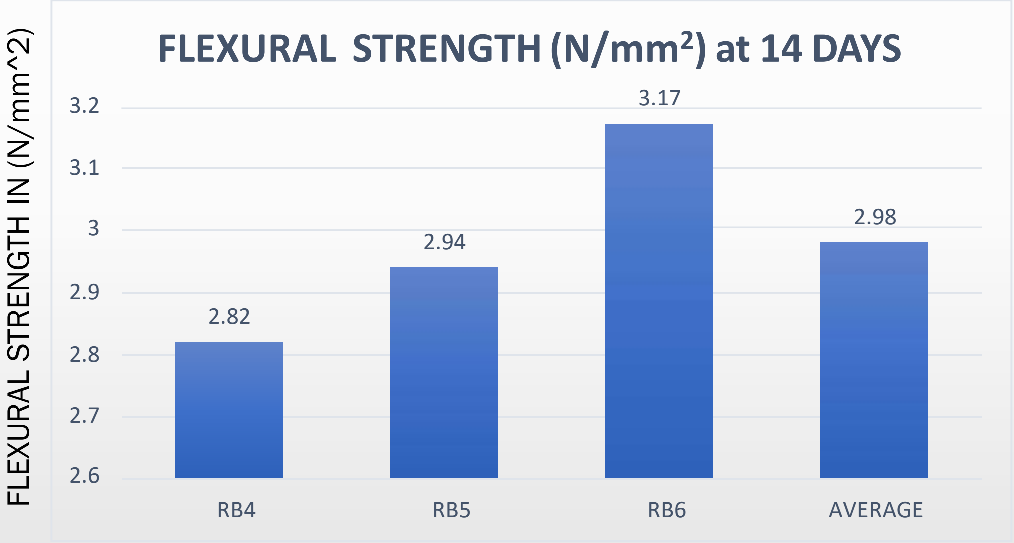
FLEXURAL STRENGTH OF CB AT 14 DAYS

SPECIMEN DETAILS	FLEXURAL STRENGTH (N/mm^2) at 14 DAYS
CB4	2.52
CB5	1.85
CB6	3.03
AVERAGE	2.47

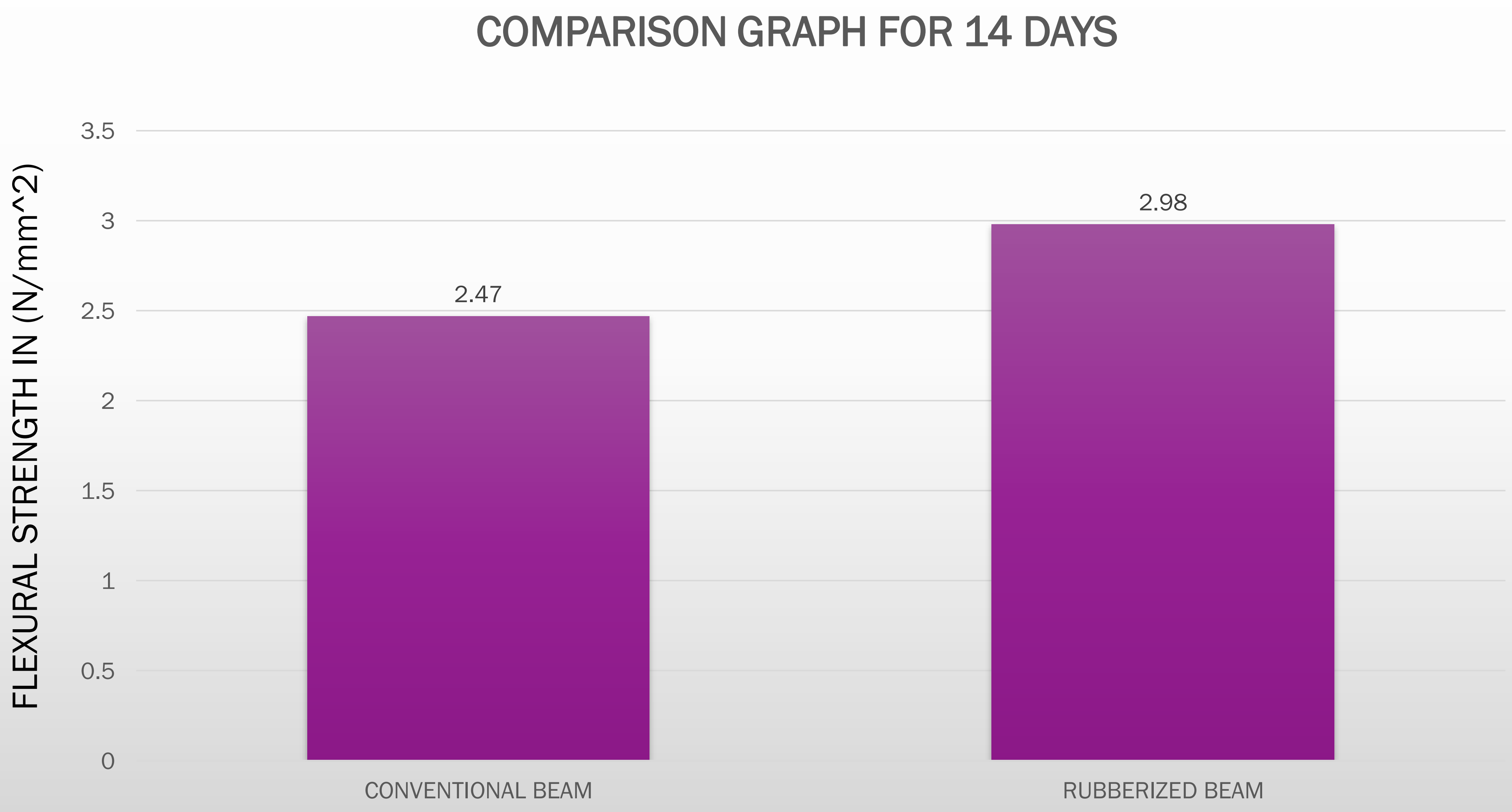


FLEXURAL STRENGTH OF RB AT 14 DAYS

SPECIMEN DETAILS	FLEXURAL STRENGTH (N/mm^2) at 14 DAYS
RB4	2.82
RB5	2.94
RB6	3.17
AVERAGE	2.98

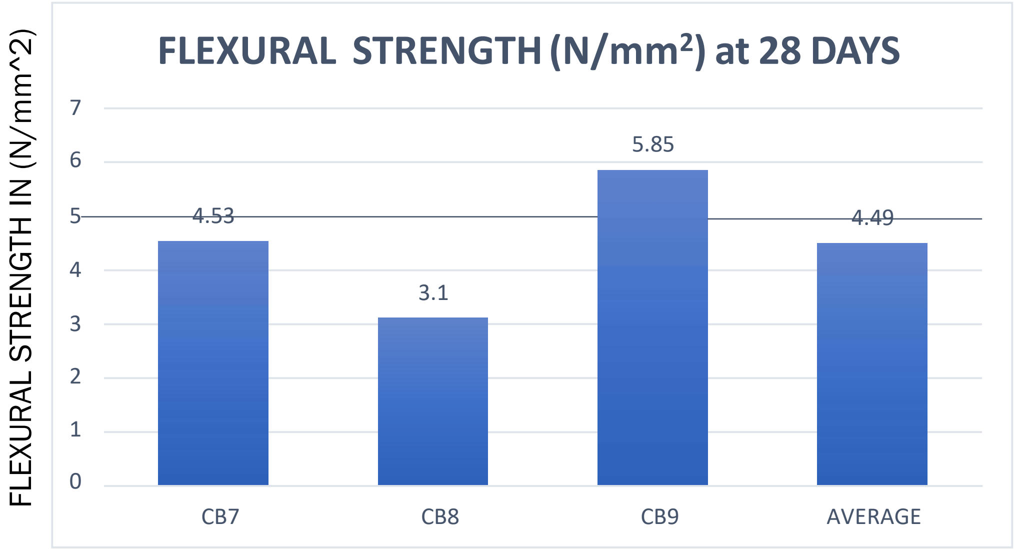


FLEXURAL STRENGTH OF CB VS RB AT 14 DAYS



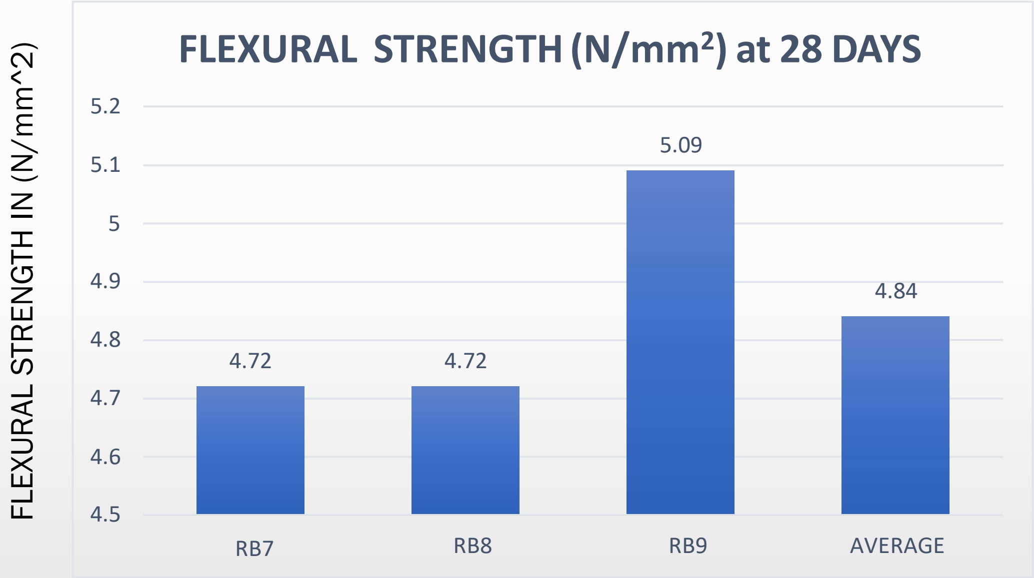
FLEXURAL STRENGTH OF CB AT 28 DAYS

SPECIMEN DETAILS	FLEXURAL STRENGTH (N/mm^2) at 28 DAYS
CB7	4.53
CB8	3.1
CB9	5.85
AVERAGE	4.49

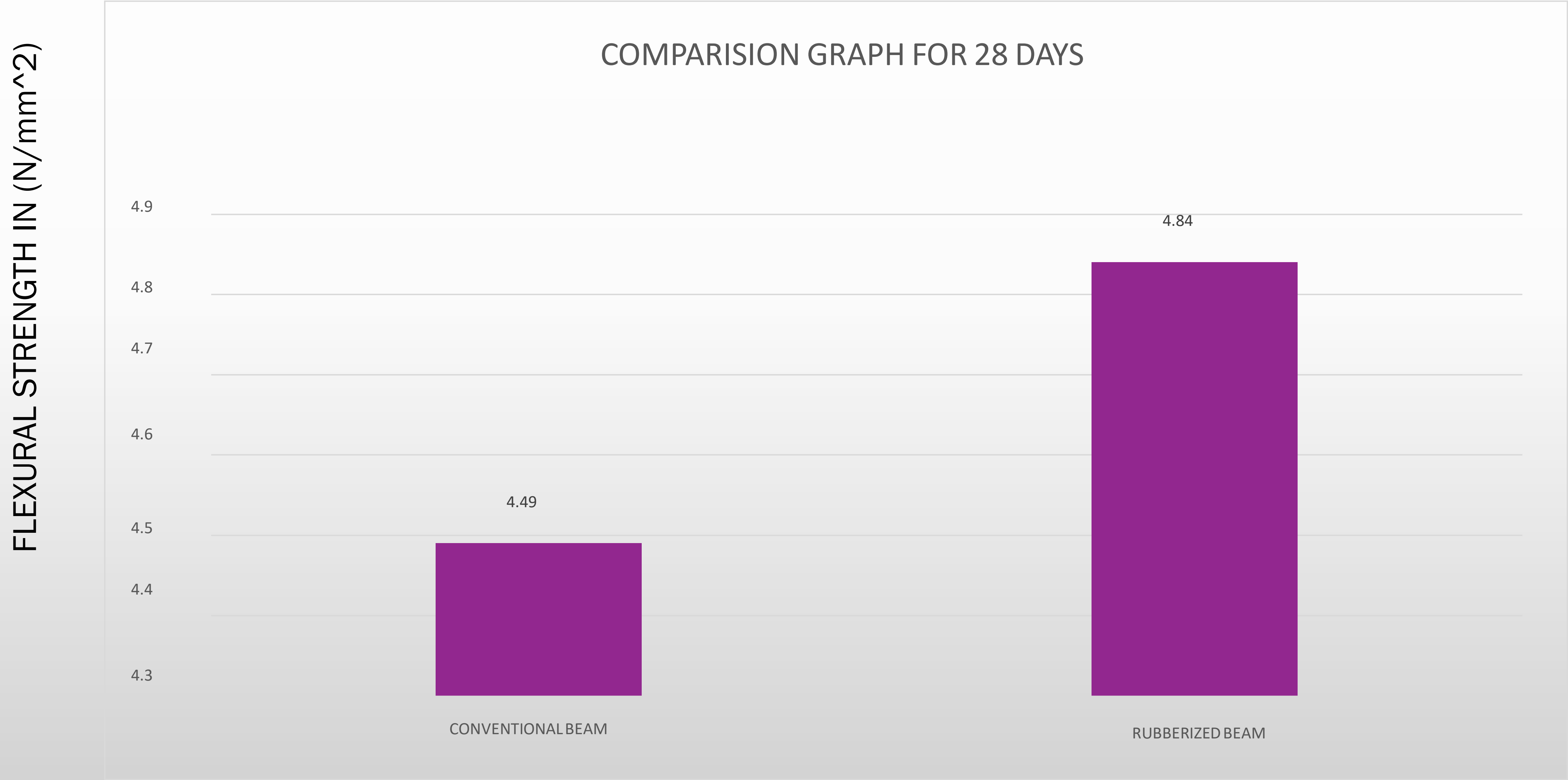


FLEXURAL STRENGTH OF RB AT 28 DAYS

SPECIMEN DETAILS	FLEXURAL STRENGTH (N/mm^2) at 28 DAYS
RB7	4.72
RB8	4.72
RB9	5.09
AVERAGE	4.84



FLEXURAL STRENGTH OF CB VS RB AT 28 DAYS



CONCLUSION

- Based on the presented experimental program, the following conclusions can be offered.

1. The installation of PVC pipes in reinforced concrete beams increases the strength and rigidity of the beams depending on sizes and locations of these pipes.
2. There is no need to take any precautions regarding the beam with central pipe if the diameter of the pipe is about or less than one third of the beams width. The most preferable location to install pipe in reinforced concrete moderate deep beams is at the center of the beams away from the tension reinforcement in order to avoid bond failure.
3. Experimental investigation revealed that rubberized beam can withstand approximately the same stress as that of conventional beam and their strength increased gradually with the curing period.
4. Therefore, beams embedded with PVC pipe filled with crumbled rubber powder can replace conventional beam due to its economy, strength and the PVC pipe can serve the purpose of conduit pipes for electrical wire installation.

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THANK YOU