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Strength Properties of Roller Compacted Concrete Pavements Containing Fly ash and Triangular Polyester Fiber

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Abstract: The use of roller compacted concrete (RCC) in pavements are widely used for a variety of industrial and heavy duty pavement application that involves low-speed traffic. The aim of this investigation is to evaluate the effect of fly ash and triangular polyester fiber (TPF) on mechanical properties of RCC mixtures addressed. Optimal water content value for the maximum dry density of each RCC mixture is one of the main concerns for mix design. In this study, an effect of TPF used as 0.25%, 0.50% and 0.75% per one cum with fly ash 15%, 30% and 45% by cement weight as a partial cement replacement on optimum water content, mechanical properties was investigated. The mechanical properties of RCC mix with TPF decrease due to water requirement increase. RCC mixtures with fly ash 30% partial replacement of cement and TPF at 90 days curing should be designed to fulfill the requirement of strength and workability.

Keywords: *RCC, Fly ash, TPF, optimum water content, mechanical properties*

Notation

OMC_{TPF}	Optimum water content of TPFRCC (%)
OMC_{RCC}	Optimum moisture content of RCC (%)
TPFD	Fiber dosage per 1 m^3 (%)
OMC_{FA}	Optimum water content of FA (%)
FAC	Fly ash content (%)
γ_w	Maimum wet density (kg/m^3)
γ_d	Maimum dry density (kg/m^3)

1. Introduction

Roller compacted concrete (RCC) is a zero slump concrete mixtures of aggregate, water, and cementing materials that no reinforcement, generally placed using in asphalt paver and compacted by vibrating roller compacting equipment [1]. RCC used for road pavement, dam construction and embankment especially for mass concreting [2]. Construction with RCC is a relatively efficient and cost-effective process and the increased placement speed of the pavement [15]. RCC mix design produced and that has sufficient paste volume and density to coat the aggregate in the mix and to fill in the voids between them using the maximum density method [20].

The performance of mechanical properties of RCC is affected several factors many researchers have studied these factors [10]. The proper mix design and compaction, the drier nature of RCC mixtures allows for strengths and that are more than conventional concrete in the same cement content [22]. The most important property of an RCC mixture is its moisture content, which is a characteristic property that indicates the amount of energy that is required to achieve the maximum density of the aggregates in the mixtures [14].

It is well known that fly ash (FA) is a waste or by-product of coal combusting based power station and has pozzolanic properties and due to its application widely used in RCC production [12]. Incorporating FA in RCC to make RCC with FA can further reduce cost with a concurrent improvement in the performance in terms of its workability, compatibility, heat evolution and prolonged strength gain [11]. Use of fly ash in RCC serves a partial replacement for the cement to reducing concrete cost; reduce the heat of hydration, and an FA adding to the concrete to provide fines to improve workability [3].

The effect of Triangular shape polyester fiber (TPF) on compressive strength and elasticity modulus were beyond expectation. Even after initial cracks, tensile and flexural strengths significantly increase as a result of adding TPF [4]. Also, TPF contributed to the ductility of concrete. Concrete is prone to have numerous micro- and macro-cracks during its setting and hardening process [16]. Several researchers have advocated the use of TPF in concrete [18]. However, they have a tendency to disintegrate in the alkaline environment of Portland cement concrete [13]. Hence, an increase in the percentage of TPF increases the flexural strength [23].

The constituent and proportion of RCC for pavements have been extensively investigated. The RCC mix designs are generally focusing on determining the optimal water content [4]. The methods at present obtainable for determining optimal water content are the modified proctor compaction method and the modified Vebe method [5].

Although the easy and accurate method used to find optimal water content, wet density and dry density of RCC by nuclear density gauge (NDG) [6]. In present

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paper used NDG measured two density modes of operation backscatter and transmission to find OMC, dry density, wet density and % compaction. The backscatter setting provides nondestructive tests and is most frequently used for asphalt and concrete pavements where drilling a transmission hole is not feasible.

In the present work, optimum water content, dry density, wet density, % compaction, mechanical properties of RCC containing the various proportion of TPF[24] as secondary reinforcement and cement replaced by FA various proportion are experimentally investigated. In this study, an effect of TPF used as 0%, 0.25%, 50% and 0.75% per one cum with FA content 15%, 30% and 45% by cement weight as a partial cement replacement on optimum water content, mechanical properties was investigated. The efficient mix design that considers different factors such as the simulations effects of fiber and FA in mixtures with OMC is of growing demand, which has received little.

2. Material and Testing

2.1 Materials

Investigators have put different viewpoints about RCC mix designs. The main difference between RCC and conventional concrete mix designs stem for low consistency and no typical gradation used in RCC [4]. Selected ingredient is directly affected by design mechanical property, durability and RCC pavement usage [1]. The different materials used to prepare RCC specimens in this study were cement, water, aggregates, FA, workability agents, and TPF. The constituent materials used in this study are procured from local sources.

In this study ordinary Portland cement of 53 grade conforming to both the requirements [7, 17]. The class F low calcium FA was used which is conforming to the ASTM standard [8]. The properties of cement and FA used in the present research are included in table 1. For all mixtures well graded sand finer than 2.36 mm was used. Normal natural course aggregate that is a crushed stone of maximum nominal size 20 mm and 10 mm was selected as coarse aggregate. Course aggregate passing through 20 mm, 12.5 mm and 6 mm and fine aggregate combined in the different fraction to match which is appropriate grading that have mentioned in the literature [1]. TPF properties are presented in table 2, were produced in India. Since the presence of TPF reduces concrete optimal water content and since RCC workability is itself very limited, FA was used whose partially replacement of cement to increase workability.

2.2 Mix Proportions

In the study the influence of FA, different content used at 15, 30 and 45% by cement weight as a partial cement replacement. Three level of TPF was used at the volume of 0.25, 0.50 and 0.75% in the mixtures. Since the presence of FA increases the workability of RCC and reduces when the presence of TPF. The RCC mixtures made with optimal water content ratio was non-workable zero slump RCC concrete using NDG. The most common moisture testing is done on compacted RCC using the NDG [6] shown in figure 1, generally used in conjunction with in-place density testing. NDG can be accomplished very quickly and is done frequently after initial compaction to smooth the surface for testing or following completion of compaction. Moisture tests obtained with a single-probe nuclear gauge (by far the most common) are only surface (backscatter) results. The moisture content obtained with this gauge is only an indication of the total moisture content of the full RCC lift and can be significantly affected by surface moisture changes, such as drying or precipitation. The moisture content of RCC at depths ranging from 50 to 600 mm (2 to 24 in.) can be obtained using a double-probe nuclear gauge. Aggregate moisture content tests should be made before the start of each shift and whenever the change is observed to adjust batch quantities appropriately.

In the present study, NDG test was used to determine OMC, dry density and % compaction for evaluating the workability of the concrete. The NDG test is described in ASTM [9]. In this procedure RCC, mixes were compacted with various water contents and the maximum dry density (γ_{dmax}) was determined. The water content in concrete mixtures was determined according to optimum water content values.

Cube sample with 150 mm a side, prism sample with the dimension of 100x100x500mm and the cylinder sample with 150 mm diameter and 300 mm height were prepared from fresh RCC mixtures. The proper and complete compaction was obtained using vibrating weighing test [19] as shown in figure 2. The preparing cube, beam and cylinder sample with proper compaction can evaluate using vibrating weighing test. The table 3 is summarized details of concrete mix proportion in this study.

2.3 Test Results and Discussion

The moisture content w, wet density γ_w, dry density γ_d and compaction ratio of all RCC mixture using NDG and given in table 4. The relation between the optimal water content and dry density for each mixture was developed by a polynomial function.

Table 1: *Cement and fly ash different Chemical composition (%by mass) and physical properties*

	Cement	Fly ash		Cement	Fly ash
Chemical composition			**Physical properties**		
Silicon dioxide (SiO_2)	20.72	59.4	Blaine fineness (m^2/kg)	312	395

Aluminum oxide (Al_2O_3)	4.65	26.5	Specific gravity	3.16	2.09
Calcium oxide (CaO)	60.3	1.91	Soundness: mm	0.06	0.03
Ferric oxide (Fe_2O_3)	4.35	5.2	Setting time: mm Initial	156	NA
Magnesium oxide (MgO)	2.41	0.97	Final	223	NA
Potassium oxide (K_2O)	0.63	0.69	Compressive Strength:(Mpa) 3 days 7 days	35.2 44.24	NA NA
Sulphuric anhydride (SO_3)	2.35	0.85	28 days	61.13	NA
LOI	2.43	1.1	Lime reactivity	NA	8.72

***Table 2:** Properties of TPF used in the experiment*

Length (mm)	**Melting Point (^{0}C)**	**Diameter (Micron)**	**Resistance to alkalis, salts, and acids**	**Ability of electrical conductivity**	**Tensile strength (N/mm^2)**	**Color**
12	240-260	30-35	High	Limited	456	White

***Figure1.** Measure dry and wet density using nuclear density gauge meter test on beam specimen*

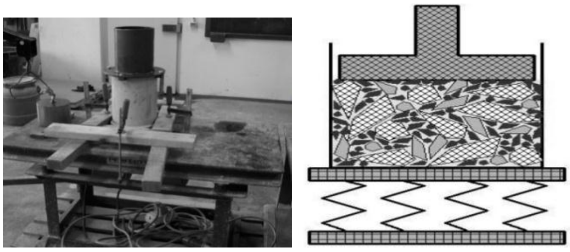


***Figure2** a) Test setup for vibrating weighing test b) Principal of the test*

According to the OMC and dry density resultant curve determine as shown in the figure 3 a) to p). The peak point of each curve in the figure represents a mix with the OMC determined by the MDD using the specified method. In this procedure, all RCC mixes compare with the relationship between optimum moisture content and maximum dry density in the figure 3 a) to p). As see this figure the dry density of RCC first increases by increasing the water content up to an optimum moisture content value. After that dry density significantly reduces by the increasing the water content. According to table 4 for all mix proportions, the OMC reduced by the addition of fly ash materials into RCC mixtures. The water demand of the mixes for the targeted workability changed as the fly ash fineness. Relation between optimum water content and maximum dry density of different proportion of fiber with and without fly ash are shown in figure 4 and figure5. In figure 4 shows that dry density of RCC mixture decreases and increase water content (%) due to fiber content increases respectively. The effect of fly ash with fiber in figure 5 shows that optimum water content decreases with increasing fly ash content. The relation between water content and dry density of RCC mixture R^2 value are more than 0.90 shown in figure 6 and figure 7.

TPF as a secondary reinforcement material has a hydrophobic surface it does not flocculate in the matrix material in the cement. It flocculates in the mixer if they are added to RCC during the mixing process. This was loss homogeneity in the mixtures. Due to this cause, the water content of the mixture increased. In table 3 and table 4, can be seen that percentage of TPF increases as water demand increases in the RCC mixtures.

According to table 3 and table 4 when the different proportion of FA combined to different content of TPF optimum water content was control due to its individual properties of FA and TPF. RCC mix increases workability when increasing FA proportion and decreases when TPF content increase. In table shows that OMC of RCC without and with fly ash varied between 5.18% and 4.979% and RCC without and with TPF varied between 5.18% and 5.714%. Maximum dry density value varied between 2384 kg/m^3 and 2392 kg/m^3 when adding FA and 2384 kg/m^3 and 2366 kg/m^3 when adding TPF. In all RCC mixes relationship between optimum moisture content and maximum dry density shows that optimum moisture content decreases with the increase of maximum dry density.

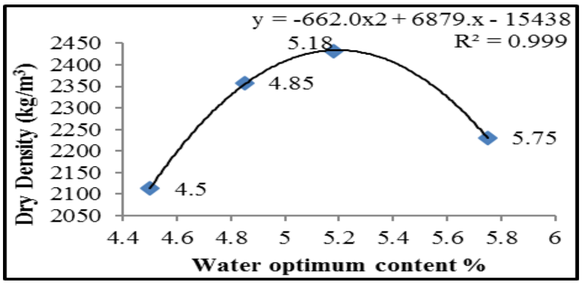
***Table 3:** Final mix design and proportion in kg/cum*

Mix design code	**Cement (kg)**	**Fly ash (kg)**	**Water (kg)**	**Coarse Aggregate (kg)**		**Fine Agg. (kg)**	**W/C+F**
				6 to 12.5 mm	**12.5 to 19 mm**		
TPF-FA0%	325	-	123.5	502	748	805	0.38
TPF-FA15%	292.5	32.5	122.1	502	748	805	0.375

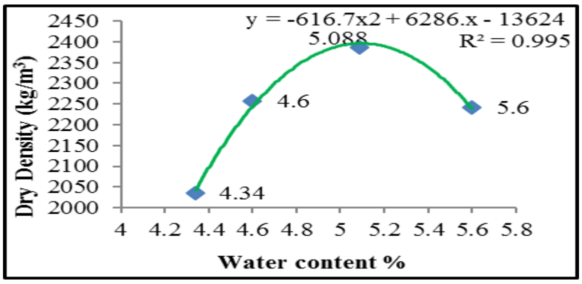
TPF-FA30%	227.5	97.5	118.5	502	748	805	0.364
TPF-FA45%	195	130	118.6	502	748	805	0.365
TPF0.25%-FA0%	325	-	127.7	502	748	805	0.39
TPF0.50%-FA0%	325	-	132	502	748	805	0.41
TPF0.75%-FA0%	325	-	136	502	748	805	0.42
TPF0.25%-FA15%	292.5	32.5	122.5	502	748	805	0.377
TPF0.50%-FA15%	292.5	32.5	125.5	502	748	805	0.39
TPF0.75%-FA15%	292.5	32.5	132.3	502	748	805	0.41
TPF0.25%-FA30%	227.5	97.5	118.7	502	748	805	0.361
TPF0.50%-FA30%	227.5	97.5	120	502	748	805	0.369
TPF0.75%-FA30%	227.5	97.5	125.1	502	748	805	0.381
TPF0.25%-FA45%	195	130	118.2	502	748	805	0.364
TPF0.50%-FA45%	195	130	118.9	502	748	805	0.366
TPF0.75%-FA45%	195	130	119.5	502	748	805	0.368

Table 4: *Optimum water content, wet density, and maximum dry density value of different RCC mixtures*

Mix proportion	W opt (%)	γ_w kg/m^3	γ_d kg/m^3
TPF-FA0%	5.18	2432	2384
TPF-FA15%	5.088	2436	2387
TPF-FA30%	4.979	2441	2392
TPF-FA45%	4.98	2438	2391
TPF0.25%-FA0%	5.366	2396	2375
TPF0.50%-FA0%	5.546	2380	2369
TPF0.75%-FA0%	5.714	2374	2366
TPF0.25%-FA15%	5.147	2432	2382
TPF0.50%-FA15%	5.273	2429	2379
TPF0.75%-FA15%	5.559	2425	2377
TPF0.25%-FA30%	4.987	2447	2388
TPF0.50%-FA30%	5.042	2439	2384
TPF0.75%-FA30%	5.256	2433	2379
TPF0.25%-FA45%	4.966	2445	2387
TPF0.50%-FA45%	4.995	2436	2382
TPF0.75%-FA45%	5.021	2424	2377



(a)



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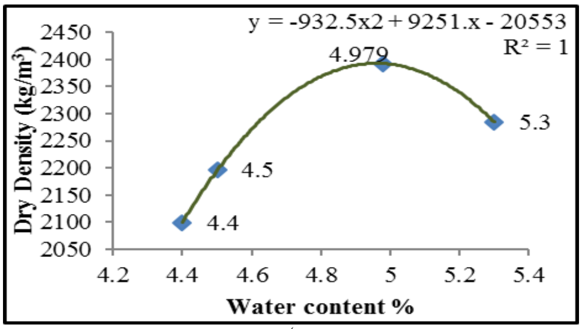

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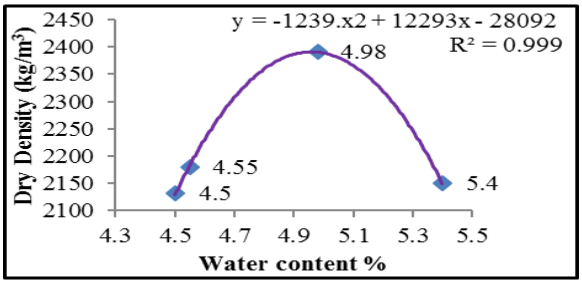

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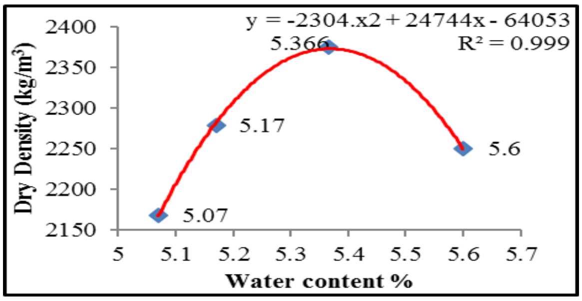

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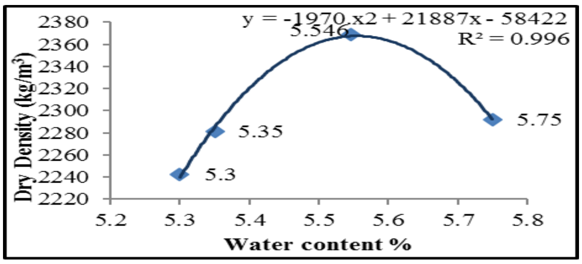
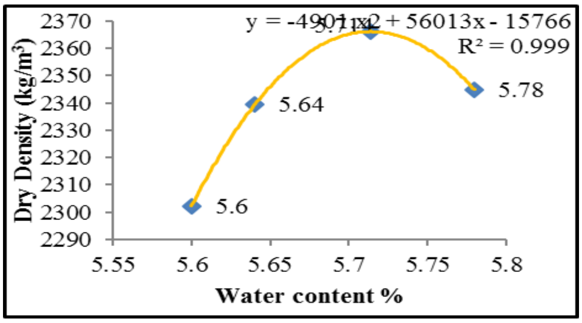
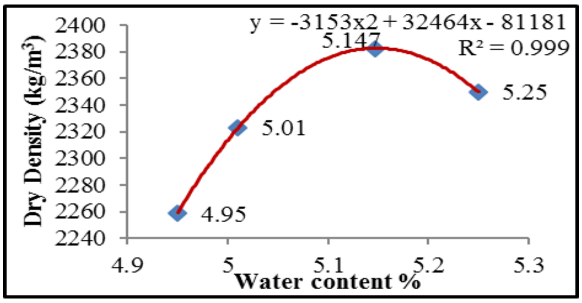


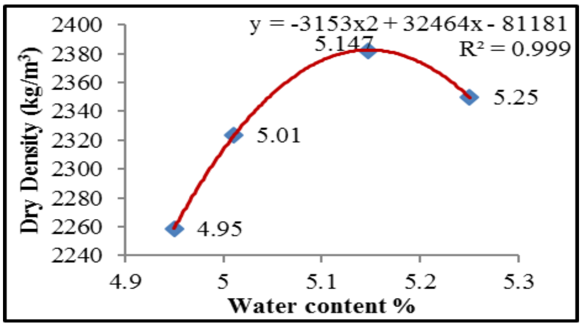
(f)


y = -4901x2 + 56013x - 15766
R² = 0.999
5.71
5.64
5.78
5.6
Dry Density (kg/m³)
Water content %

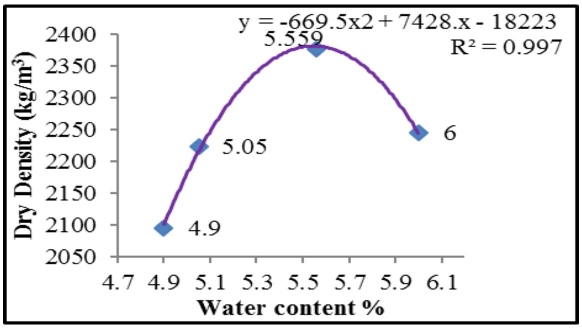
(g)


y = -3153x2 + 32464x - 81181
R² = 0.999
5.147
5.01
5.25
4.95
Dry Density (kg/m³)
Water content %

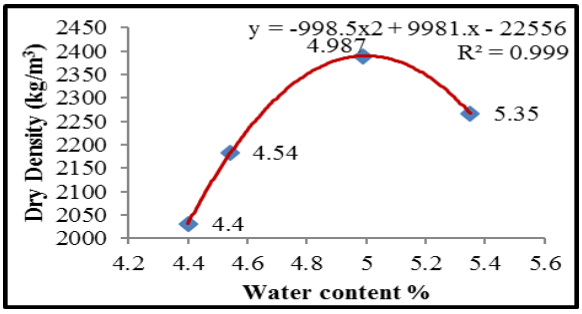
(h)


y = -3153x2 + 32464x - 81181
R² = 0.999
5.147
5.01
5.25
4.95
Dry Density (kg/m³)
Water content %

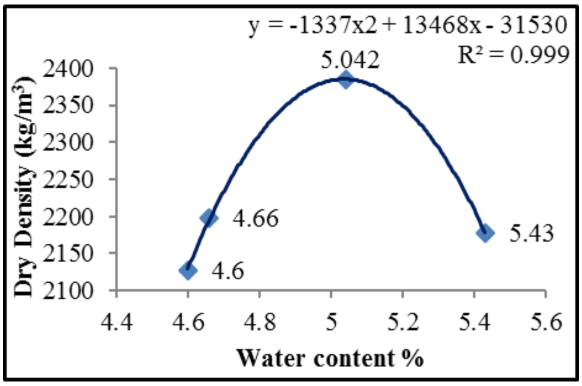
(i)


y = -669.5x2 + 7428.x - 18223
R² = 0.997
5.559
5.05
6
4.9
Dry Density (kg/m³)
Water content %

(j)


y = -998.5x2 + 9981.x - 22556
R² = 0.999
4.987
4.54
5.35
4.4
Dry Density (kg/m³)
Water content %

(k)


y = -1337x2 + 13468x - 31530
R² = 0.999
5.042
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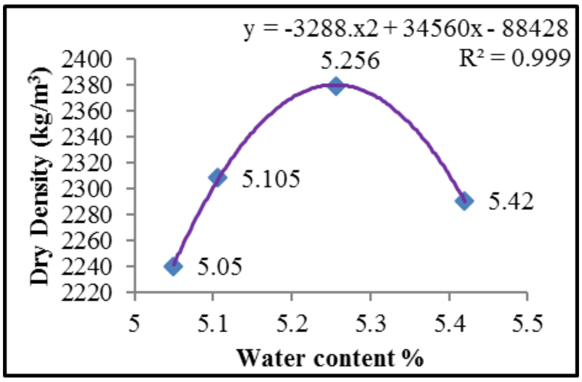
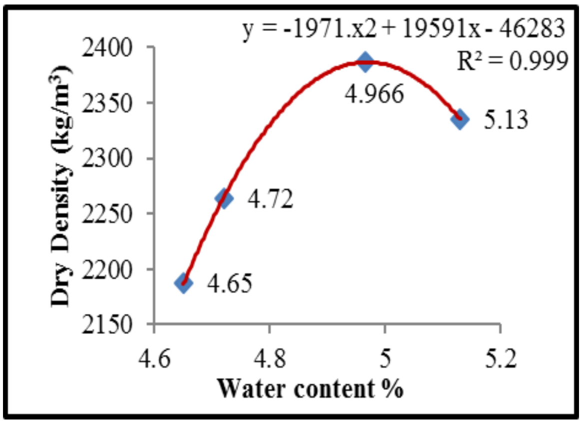
5.43
4.6
Dry Density (kg/m³)
Water content %

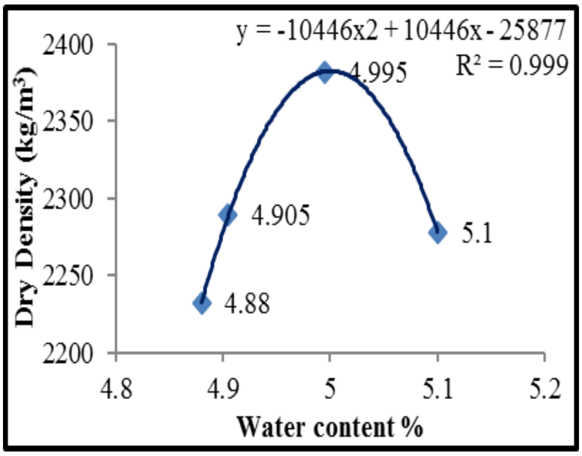
(l)


y = -3288.x2 + 34560x - 88428
R² = 0.999
5.256
5.105
5.42
5.05
Dry Density (kg/m³)
Water content %

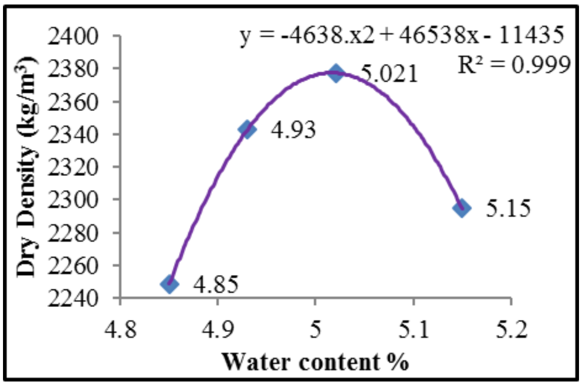
(m)


y = -1971.x2 + 19591x - 46283
R² = 0.999
4.966
5.13
4.72
4.65
Dry Density (kg/m³)
Water content %

(n)


y = -10446x2 + 10446x - 25877
R² = 0.999
4.995
4.905
5.1
4.88
Dry Density (kg/m³)
Water content %

(o)



(p)

***Figure 3** Relation between water content % maximum dry density of mixture a) TPF+FA0%, b) TPF+FA10%, c) TPF+FA30%, d) TPF+FA45%, e)TPF0.25%-FA0%, f)TPF0.50%-FA0%, g)TPF0.75%-FA0%, h)TPF0.25%-FA15%, i)TPF0.50%-FA15%, j)TPF0.75%-FA15%, k)TPF0.25%-FA30%, l)TPF0.50%-FA30%, m) TPF0.25%-FA0%, n) TPF0.50%-FA0%, o)TPF0.25%-FA0%, p)TPF0.50%-FA0%*

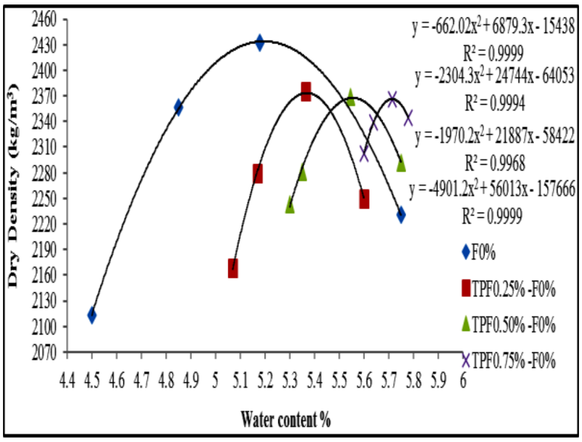


***Figure 4** Relation between optimum water content and maximum dry density of TPF0.25%-FA0%, TPF0.50%-FA0% and TPF0.75%-FA0%*

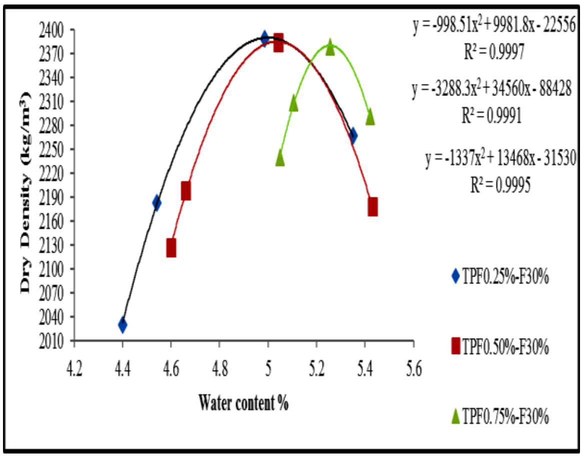


***Figure 5** Relation between optimum water content and maximum dry density of TPF0.25%-FA30%, TPF0.50%-FA30% and TPF0.75%-FA30%*

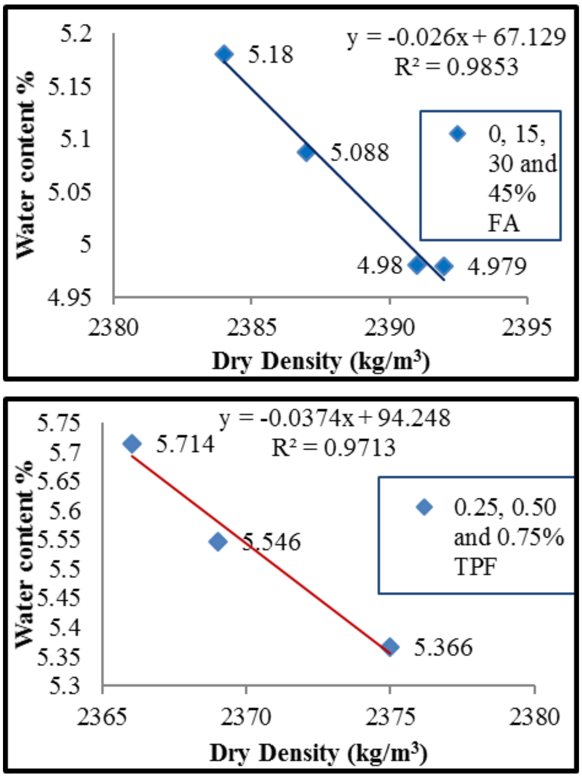


***Figure 6** Relationship between optimum water content and maximum dry density of all RCC mixtures*

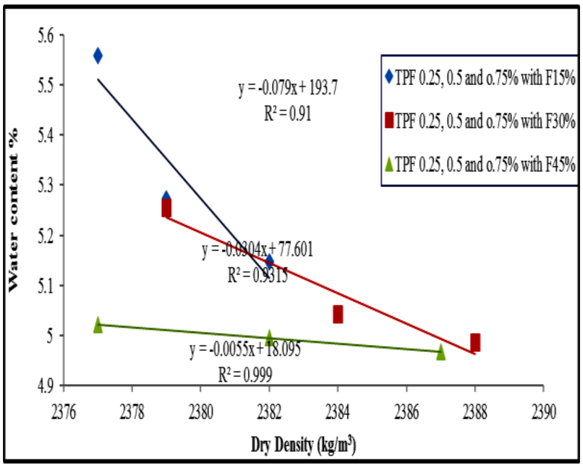


***Figure 7** Relationship between optimum water content and maximum dry density of TPF0.25%, 0.50% and 0.75% with F15% mixtures*

The result is compare with the following linear relationship between optimal moisture content and TPF content

$$OMC_{TPF} = OMC_{RCC} + 0.744\ TPFD \quad \text{(Equation 1)}$$
$$OMC_{FA} = OMC_{RCC} - 6.133 \times 10^{-3} FAC \quad \text{(Equation 2)}$$

Where, OMC_{TPF} is the optimum water content of TPFRCC in percentage, OMC_{FA} is the optimum water content of FA in percentage, OMC_{RCC} is the optimum moisture content of RCC, and TPFD is the fiber dosage per $1m^3$ in percentage, FAC is the fly ash content in percentage by cement weight as a partial cement replacement.

3. Mechanical Properties

3.1 Compressive Strength

The test result of compressive strength 7, 28 and 90 days curing of RCC, RCC with FA, and RCC with TPF and TPF-FA mixtures are shown in table 5. It can see from test result an FA admixed concrete, the strength of 7d and 28d is mainly contributed by hydration of cement and FA contributes to its long-term strength. The most significant increase in compressive strength of FA concrete mixtures at 90 days over 7 days and 28 days strength, of control mix of RCC, understandably due to the contribution of pozzolanic reactivity of fly ash. The 7 days compressive strength of concrete mix decreases from 32 to 20 Mpa and 28 days strength decreases 40 to 32 Mpa as the FA content an increases from 0% to 45 %. The 90 days compressive strength of concrete mix increases as the fly ash content F30 and decreases as the fly ash content F40. It can see from table compressive strength increases from 48 to 52 Mpa.
The compressive strength of the concrete mix with TPF is present in table 5. It can be seen that the compressive strength of RCC and TPFRCC after 7, 28 and 90 days varied between 32 to 25 Mpa, 40 to 30 Mpa and between 48 to 37 Mpa respectively. The compressive strength of TPFRCC mix decreases as the TPF content increases. The table 3 shows that optimal w/c increases as the TPF content increases, due that strength of TPFRCC mixture decreases.

The compressive strength of the RCC mix with fly ash and TPF are present in the table 5. In a result shows that optimal w/c ratio of combined mixture of fly ash and TPF are control due to its individual property. Optimal water content increases when the percentage of fly ash increases up to 30% and decreases when the percentage of TPF increases. It can combine fly ash and TPF optimal w/c ratio control and increase the strength of RCC mix. The strength of all the TPFRCC with 0.25, 0.50 and 0.75% mixture and fly ash adding 15, 30 and 45% in this control mix strength increases at 90 days. The 7d and 28d compressive strength of TPF with fly ash different proportion of mixtures strength varied between 30 to 19 Mpa and between 36 to 26 Mpa. The 90 d compressive strength of same mixtures increase and varied between 46 to 51 Mpa.

RCC is generally required to have a compressive strength of 30 to 35 Mpa at 28 days. The 28 days compressive strength of TPF0.25%-FA30 mixture with water cement ratio 0.361 and TPF0.50%-F30 with water cement ratio 0.369 was 36 and 34 Mpa, respectively. Thus, RCC containing 30% FA and 0.25% to 0.50% TPF shall be designed to achieve the strength requirement for RCCP. As per IRC: SP: 62-2014 and ACI 325.10R-95 compressive strength of RCC at 28 days at least 30 Mpa, mixtures are satisfied.

Table5 *Optimum water content, wet density, maximum density value and Mechanical properties of different RCC mixtures*

Mix proportion	Compressive Strength Mpa			Flexural Strength Mpa			Split tensile Strength Mpa		
	7 days	28 days	90 days	7 days	28 days	90 days	7 days	28 days	90 days
TPF-FA0%	32	40	48	2.4	3.9	4.4	2.7	2.9	3.2
TPF-FA15%	30	33	49	2.1	4.0	4.7	2.5	2.9	3.2
TPF-FA30%	25	38	52	1.7	4.3	5.2	1.7	3.2	3.4
TPF-FA45%	20	32	41	1.5	3.7	4.2	1.9	2.8	3.1
TPF0.25%-FA0%	30	32	46	3.3	4.9	5.3	3.4	3.8	4.3
TPF0.50%-FA0%	28	31	42	3.5	5.5	5.9	3.7	4.0	4.6
TPF0.75%-FA0%	25	30	37	4.1	5.8	6.1	3.4	3.5	4.1
TPF0.25%-FA15%	30	32	46	3.4	4.9	5.4	3.5	3.8	4.4
TPF0.50%-FA15%	29	30	44	3.5	5.5	5.8	3.9	4.0	4.8
TPF0.75%-FA15%	26	29	41	4.2	5.8	5.9	3.5	3.7	4.1
TPF0.25%-FA30%	24	36	51	3.6	5.1	5.5	3.7	4.1	4.7
TPF0.50%-FA30%	22	34	49	3.7	5.8	5.9	3.8	4.2	4.8
TPF0.75%-FA30%	21	31	45	3.8	6.0	6.1	4	4.5	4.9
TPF0.25%-FA45%	20	31	42	3.7	5.2	5.6	3.9	4.2	5.0
TPF0.50%-FA45%	21	29	40	3.8	5.9	6.0	4.1	4.4	5.0
TPF0.75%-FA45%	19	26	38	3.9	6.2	6.3	4.3	4.6	5.2

3.2 Flexural Strength

Test results for the effect of fly ash and TPF with different proportion given in table 5. As seen table 5 flexural strength decreases in 7d and 28 d curing with increasing fly ash content. The 7 days flexural strength of control mix FA0 is 2.4 Mpa, which is decrease to 1.7 Mpa in the case of FA40. The 28 days flexural strength of control mix FA0 is 3.9 Mpa, which is increased to 4.3 Mpa in the case of FA30 and deceases in the case of FA40 that is 3.7. The flexural strength at the age of 28 days and 90 days curing of concrete mixtures containing from 15 to 30 % fly ash more than the strength of RCC control mixtures. The 90 d curing flexural strength result shows that RCC mixture with 30 % fly ash was 5.2 Mpa.

The flexural strength results obtained from the table 4 when adding TPF with 0.25%, 0.5% and 0.75% per 1 m^3 in RCC control mixtures. Flexural strength of RCC and TPFRCC varied between 4.4 to 6.1 Mpa at 90 d curing. The TPF content increases in RCC mixtures flexural strength increases and decreases without fiber. Adding TPF not only the ductility but also the energy absorption capacity of the specimen increases.

Table 4 shows the influence of TPF content on the flexural strength, for the different amount of fly ash used in each mixture. As seen in the mixtures containing FA0% and FA15% with TPF with different content are less effect on the flexural strength of the fibreless mixtures. The flexural strength of RCC, mixtures increases containing FA30% when TPF added with 0.25%, 0.5% and 0.75%. It can see that 0.75% TPF with FA30% mixtures higher strength. As per IRC: sp: 62-2014 and ACI 325.10R-95 compressive strength of RCC at 28 days at least 3.5 to 7 Mpa, mixtures are satisfied.

3.3 Split Tensile Strength

The splitting tensile strength of the RCC mixtures is present in table 5. The splitting tensile strength results decrease in 7d and 28 d with increasing fly ash content. The split strength at the age of 28 days and 90 days curing of concrete mixtures containing from 15% to 30 % fly ash more than the strength of RCC control mixtures. The result shows in table 4 TPF with 0.25%, 0.5%, and 0.75% adding in control mixture. It can be seen that splitting tensile strength results of RCC and TPFRCC sample after 7d curing varied between 3.4 to 3.7 Mpa. 28d and 90d curing splitting tensile strength varied between 3.5 to 4.0 Mpa and between 4.1 to 4.6 Mpa respectively. In control mixtures testing according to a brittle behavior and with TPF cylinder sample were fractured according to ductile behavior.

The fly ash and TPF adding with different proportion in control mixture result shown in table 4. The results show that FA0% and F15% with 0.25% TPF, not any major effect on splitting tensile strength of the fibreless mixtures. The 7d, 28d and 90d curing splitting tensile strength increase with increasing fly ash and TPF content. 7days, 28d and 90d curing splitting tensile strength varied between 1.7 to 4.3 Mpa, 2.8 to 4.6 Mpa and between 3.1 to 5.2 Mpa respectively. As per ACI, 325.10R-95 split tensile strength of RCC mixtures is satisfied.

4. Conclusion

As a result of this laboratory investigation, the following conclusion can draw,

The optimum water content and W/C+F value of the RCC mixes with the addition of fly ash content are grater that those of without fly ash. In mechanical properties of RCC mixes containing FA30% as cement replacement was initially 7 days curing decrease strength and higher strength property and workability at 28 and 90 days curing due to pozzolanic contribution.

The RCC mix with TPF of optimum water content values and W/C+F ratio are decreases. Results obtained from the RCC mixes with TPF flexural behavior significantly increase but peak compressive strength reduce slightly due to W/C ratio decreases. RCC mixes can be successfully proportion with FA30% with TPF increases mechanical property at 28 and 90 days curing.

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