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Investigation of the Mechanical, Corrosion Characteristics of Steel using Geopolymer Coatings

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ABSTRACT-*Corrosion of metal in concrete shapes is a worldwide hassle regarding the sturdiness of concrete structures. Many corrosion safety techniques are to be had on inside construction. Among the safety types, coatings play a main role. Most widely, epoxy coatings are utilized in practice. Epoxy primarily based totally, metal rebar coatings are solvent primarily based totally and as placing vaporizes the solvents which produces inexperienced gases and once more a difficulty of worldwide warming. By thinking about sick effects, an try is made via way of means of systematic look at on the utility of geopolymer coatings for prevention of corrosion of metal rebars in concrete. However, such coating generates chemical poisonous and inexperienced residence gases to the surroundings and it pollutes the ecosystem air all through the manufacture and coating periods. In this gift paper a metal rebar coatings are evolved and studied for diverse testing strategies and the use of geopolymer binder as coating material. This offers sufficient safety residence towards corrosion of metal. Twenty coatings are evolved primarily based totally on geopolymer binder and the satisfactory one coating became decided on for corrosion safety. This has been decided on primarily based totally on diverse bodily and mechanical research; all consequences are provided and mentioned in detail.*

Keywords: Durability; Coatings; Corrosion; Geopolymer; Binder

1. INTRODUCTION

The necessity of offering supplementary safety to metallic rebars while the shape uncovered by the open ecosystem and in chloride act made the researchers to analyze for corrosion safety techniques. Many corrosion safety techniques are to be had on inside creation [1]. The corrosion safety techniques involving defensive floor coating can also additionally use epoxy coating on metallic rebars and corrosion inhibitors inside concrete.While coating reinforcing bars had been applied in creation throughout the beyond decades. They had been beneficial to lessen the corrosion with inside the RCC systems [2]. Therefore, diverse floor coatings are used to save you the degradation of concrete rebar shape. However, such coating produces chemical, poisonous, and inexperienced residence gases to the surroundings and it pollutes the ecosystem throughout the manufacture and coating periods. However, the anti-corrosive coating,the compounds of geopolymer (Sodium Silicate & Sodium Hydroxide), includes much less polluted substances and now no longer generate poisonous and inexperienced residence gases inside the ecosystem [3]. Anti corrosive coating has the benefit of excessive early power, low shrinkage, hearth place resistance, and suitable chemical resistance. Fly ash, metakaolin, and furnace slag are the by merchandise constituted of the enterprise and that they have been used as raw substances for education of anti-corrosive coatings. This anti-corrosive coating gives a modern and sustainable answer to saving you from corrosion, warmth, and abrasion resistant. Anti corrosive coating fabric is additionally excessive in adhesion power among current systems that fits for coating discipline application.

2. MATERIALS AND COATING FORMULATIONS:

A. Test samples:

The size and removal of coating sharpness requirements for cleaning and cleaning agents were made using 100mm x 150 100mm x 75mm foils to assess flexibility, usability, and strength. Clean and clean with a cleaning diameter of 8mm. Then dry in an oven at 60°C before applying the selected topcoat. 100mm x 150mm10mm x 750mm stucco board and 8 pcs of 10mm rice flour with millimeter flour ash, OPC micro silica fume, rice husk ash, garnet, china clay, kaolin, ferrosilicon powder, vanadium pent oxide (V2O5), Fe2O3, Al2O3, TiO2 and silica fume are used as filler materials. The chemical composition of the filler material is shown in Table 1. The Test Specimens after surface cleaning as shown in Fig.1.

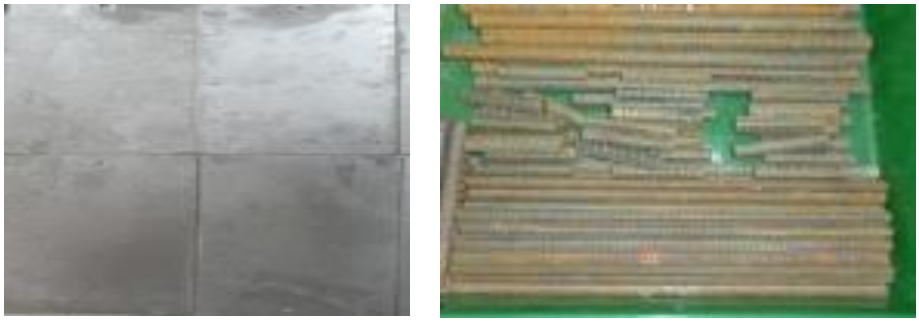

Fig.-1: Test Specimens after surface cleaning

B. Coating guidance:

The metallic coatings had been decided on to symbolise the following 20 time-honored types. The binder answer incorporates NaOH and Sodium silicate. The information on the numerous substances and their mixtures for the guidance of the coatings has been given in Table 2.

3. MECHANICAL TEST ON COATED SPECIMENS:

A. Estimation of the thickness of the coating:

The thickness of the coating on the lined plate became measured as proven in Fig.2.with the aid of using Elcometer, Great Britain. The Elcometer device was saved perpendicular to the lined plate while the measuring was carried out. The dried movie thickness of the coating became measured at numerous locations on the plate and a median fee of the thickness became taken for the study. The common thicknesses of the studied coatings have been proven in the table.3

B. Film adhesion takes a look at:

This takes a look at, and gives a standard, dependable, and reproducible approach for measuring the adhesive power of the coating movie on the steel substrate. The device used for measuring adhesive power became the "Tensometer", that is electrically operated and is so designed that the tensional pressure may be carried out perpendicular to the lined surface, while the lined specimen became held vertically. The Tensometer device is proven in Fig. 3. This takes a look at becoming carried out on all twenty coatings and the outcomes are stated in Table 3.

Fig.-2: Measuring coating thickness

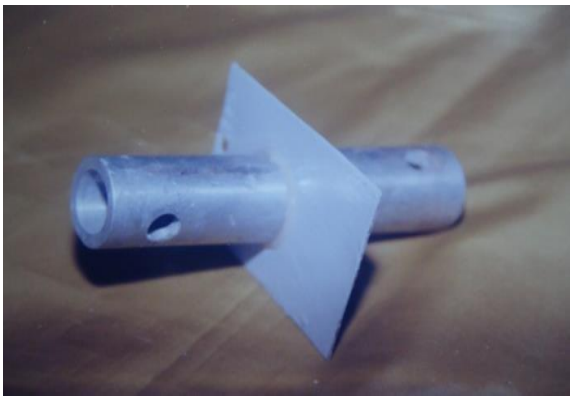

Fig.-3: Film Adhesion Test

C. Flexibility Test on metal plates (ASTM D522):

The Bend ability take a look at turning into performed through a conical mandrel bend, take a look at the equipment as consistent with ASTM D522 standards. The tool was turned into bought from M/S Sheen devices Ltd., Richmond, and Survey, England. The skinny plate of 100mm x 150mm x0.8mm turned into used to inside take a look at. Fig. 4. illustrates the shape of mandrel conical equipment, one quit of the equipment is 3mm diameter which progressively will increase as much as 38mm diameter with the quit of the length (200mm). The plates had been constant inside conical mandrel bend equipment, and tighten the wing nuts with the use of a rolled handle. The skinny plate turned into bent as much as 180o in an unmarried step. Cracks had been located from 3mm diameter in the direction of better quit of the plate. The wing nuts had been loosened to take out the bent plate. The bent plates had been proven in Fig. 5.The cracks, if any, had been measured and the outcomes had been proven in Table.3.

Fig.-4: Conical Mandrel Apparatus

Fig.-5: Bent Plates

D. Bendability Test on Rods (IS 1599:1985):

After pretreatment in triplicate, immediately deformed cold twisted bars of 8 mm, 10 mm, 12 mm, and 16 mm in diameter were coated. These bars were subjected to a bending check with a mandrel. The pin is changed to regular with clean plastic sheets at the guide so that when bending operation no damage was modified induced to the coating through the manner of approach of the mandrel. Immediately the coated bars are bent at 450 and 900 from its precise immediate line. During and after the bending operation, the covered ground on the metallic bar is modified into deciding for the development of cracks, fissures, disbandment, straining, domination, discoloration etc. Fig.6. indicates the bent rods. Observed effects have been reported for selected coatings in Table 4.

E. Impact takes have observed plate (ASTM D 2794):

The impact takes have a take a observe modified to completed as consistent with ASTM D 2794 standards. A thin plate of the period 100mm x150mm x0.8mm becomes modified to apply for the take a look. The plate was modified into place at the bottom of the gadget which was modified into demonstrated in Fig.7. And the outcomes taken as a take a observe on the plates were demonstrated in Fig.8. A piston of mass 2 lb (or) 8.89 N was modified to freely bring to the plate from a pinnacle of 30cm and 60 cm. The two edges of the slabs were subjected to shock, and the capacity of resistance to direct and indirect shocks of the coating was rewarded. The effects are shown in Table 3.

Fig.-6: Bended rods

Fig.-7: Impact Test apparatus

F. Coated Bar Impact Test (ASTM D1496):

This check approach makes use of a falling weight having a precise diameter effect surface tub that is limited vertically and dropped from various heights to produce effect energy over the required range. Impact resistance is decided as the amount of electricity required to reason the penetration of the coating film. The check equipment is just like the check defined in check approach D14 of the ASTM standard. A covered rod became held flat at the lowest of the drop tube. The wing bolt became raised via the entire top of the drop tube or manual tube in order that the bath became lifted to the top. When the wing bolt became launched suddenly, the bath nostril became dropped and was influenced by the metal rod. Care became taken in order that the effect befell between the bar deformation and ridges. For a complete top of fall, the effective pressure of 9 N. m. strikes at the coating. The impacted area became tested for any disbandment of the coating that became completely deformed with the aid of using the bath. 8, 10, 12, and sixteen mm diameter covered rods have been used for this check and the check consequences have been stated in Table3.

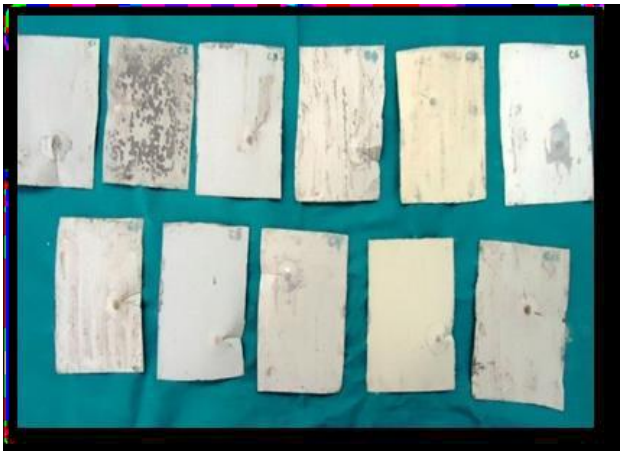

Fig.-8: Impact Test on plates

Table-1: Chemical Composition of Mineral Constituents

Material used	SiO2	%	Al2O3	%	Fe2O3	%	MgO
Fly ash	46.16	24.14	11.55	-	35.05		2.4
China clay	68	21	0.05	-	-	Na2O-1%	1.95
Micro silica	97	0.5	0.1	0.3	0.3		2.3
Rice husk ash	94.04	0.249	0.136	0.442	0.622	Na2O-0.023, K2O-2.49	2.16
Kaolin	46.55	39.5	-	-	-	-	2.62
Ferrosilicon	78.281	0.459	11.40	1.120	1.212		2.2
Clay	65.559	15.119	11.70	0.729	1.356		1.82

Table-2: Composition of different coating systems

Coating No.	Materials used	Coating No.	Materials used
GPR	Binder + Fly ash with Red oxide	GP10	Binder + Fly ash + Clay
GP1	Binder + Fly ash with yellow oxide	GP11	Binder + Fly ash + China clay
GP2	Binder + Micro silica	GP12	Binder + Fly ash + Rice hush ash
GP3	Binder + Fly ash + Micro silica	GP13	Binder + OPC + Clay
GP4	Binder + OPC	GP14	Binder + OPC + China Clay
GP5	Binder + OPC + Fly ash	GP15	Binder + OPC + Rice husk ash
GP6	Binder + OPC + Micro silica	GP16	Binder +FA+ Ferrosilicon powder
GP7	Binder + OPC + Fly ash + Micro silica	GP17	Binder + OPC + Ferrosilicon powder
GP8	Binder + OPC + Kaolin	GP18	Binder + OPC + Venadium Penta oxide(V2O5)
*Binder =1/2 molar NaOH + Sodium Silicate,			

Table-3: Results of Mechanical tests of Coatings

Designation of coating	Coating Thickness (µm)	Adhesion Test		Flexibility Test (ASTM D522)	Impact Test	
		Load at Failure	Stress at Failure		On coated plates	On coated rods ASTM D14
GPR	220	6.785	13.819	P	P	P
GP1	226	7.102	14.464	P	P	P
GP2	210	7.631	15.541	P	P	P
GP3	223	6.992	14.240	P	P	P
GP4	219	6.846	13.943	P	P	P
GP5	210	6.911	14.075	P	P	P
GP6	238	7.814	15.914	P	P	P
GP7	238	7.213	14.690	F	P	P
GP8	229	4.171	8.494	P	F	F
GP9	221	9.150	18.635	P	P	P
GP10	227	10.123	20.617	P	P	P
GP11	237	11.632	23.690	P	P	P
GP12	231	11.941	24.319	P	P	P
GP13	203	3.982	8.120	F	F	F
GP14	214	7.010	14.276	P	P	P
GP15	211	6.812	13.873	P	P	P
GP16	221	3.991	8.128	F	F	F
GP17	237	4.671	9.513	P	P	P
GP18	218	7.776	15.837	P	P	P
GP19	214	6.914	14.081	P	P	P

Note: Area of contact was 491mm^2

Table-4: Results of Bendability Test on Rods

Sl. No.	Coating No.	8mm ϕ^r		10mm ϕ^r		12mm ϕ^r		16mm ϕ^r	
		45^0	90^0	45^0	90^0	45^0	90^0	45^0	90^0
1	GPR	P	P	P	P	P	P	P	P
2	GP1	P	P	P	P	P	P	P	P
3	GP2	P	P	P	P	P	F	P	P
4	GP3	P	P	P	P	P	P	P	P
5	GP4	P	P	P	P	P	P	P	P
6	GP5	P	P	P	P	P	P	P	P

7	GP6	P	P	P	P	P	P	P	P
8	GP7	P	P	P	P	P	P	P	P
9	GP8	P	P	P	P	P	F	F	F
10	GP9	P	P	P	P	P	P	P	P
11	GP10	P	P	P	P	P	P	P	P
12	GP11	P	P	P	P	P	P	P	P
13	GP12	P	P	P	P	P	P	P	P
14	GP13	P	P	P	P	F	F	F	F
15	GP14	P	P	P	P	P	P	P	P

4. RESULTS AND DISCUSSION

All fifteen coatings primarily based totally on geopolymer binder have been subjected to mechanical and corrosion checks to discover the high-quality coating and can be made as a protective coating for the metal reinforcement of concrete.

A. Coating Thickness:

The thickness of the coating can become measured, with the use of a reachable virtual show thickness measuring tool as implied. Upon every covered floor, 6 to eight measurements are averaged, and the common values have been lied in among 210 to 237micrometeres.This coating thickness is called the dry film thickness (dft).

B. Adhesion Test:

Adhesion taking look at on the coating has been executed with the aid of using the use of a Tensometer. In which a perpendicular pressure is carried out towards the covered floor. The load at failure becomes referred to from the virtual show of the tool. For each coating and the corresponding stresses are finite and pronounced in Table 3. Since the coating becomes carried out on the phosphate floor, many coatings have been localized with less adhesive stress due to the absence of anchoring on the metal substrate. The phosphating over the pickled floor supplied a passive movie which supplied an easy floor, and this phosphating movie resisted the corrosion of the substrate metal. Poor coating energies become located for GP13 and GP16 and their corresponding values have been 8.12N/mm2 and 8.128 N/mm2, respectively, towards the very best price of 24.319 N/mm2 for GP12. In popular, excessive adhesive energy has become acquired for the coatings GP9 to GP12. The geopolymerisation of the coating with clay cloth and rice husk ash with delivered Al2O3 has helped the coating of a sturdy method of geopolymer coating. Therefore the cause for excessive adhesive energy can become the method of silate with the aid of using alumina silicate substances with the geopolymer binder.

C. Flexibility test (ASTM D522):

The flexibility of covered plate becomes located with the aid of using conical mandrel, take a look at wherein a covered plate becomes rolled to conical form with an assist of a deal and cone as proven. The coatings have been located with to none signal of cracks at the conical floor and have been taken into consideration as “handed”. If the cracks are located along the covering of the fold, they have been distinctive as "bankruptcy". This take look at has been executed for all twenty specimens and the effects have been pronounced in desk 3. The coatings GP7, GP13, and GP16 have been failed on this conical flexibility take a look at. The compositions of these types of 3 coatings have been silicate wealthy coatings and the most effective Al2O3 became delivered. The silicate richness of the composition provided a rigid geopolymer formation. So these 3 coatings failed in flexibility, take a look.

D. Impact Test:

Impact take look at has been executed at the covered MS plate as in step with ASTM D2794 and further effects take a look at executed at the covered rods additionally as in step with ASTM D14. This has been illustrated in Figs 6 & 7 on effect of the metallic ball on the covered plate floor will depart the mark of dispersion after the effect. The impacted plate could be tested and the opposite aspect with the assist of magnifying glass for the formation of cracks, fissures, and delimitation. If each plate and covered rods do now no longer exhibit defects, then they have been rated as handed and the defected coatings have been marked as failed. The effects have been given in Table 3.

E. Bendability take a look at on rods (IS 1599:1985):

Coated rods have been having 4, one -of-a--a-kind diameters together with 8, 10, 12, and 16mm which have been subjected to bending, take a look at as much as 450 and 900. After the bent, every covered floor can become tested with magnifying glass for any formation of cracks, fissures, delimitation, and discolourization because of strain awareness to the bent. If one of the identified defects is classified as defect (F), in any other case, it exceeds (P). 8mm and 10mm rods have been handed out with the studied coatings, however for 12 and 16mm failed in GP13. From all above take a look at the effects the coatings, GP10, GP11, GP12, GP14 & GP15 carry higher in anything you recognize with mechanical strength and corrosion.

5. CONCLUSION:

It may be concluded from this have a look at that the chosen coating structures have suitable mechanical residences for shielding the reinforcing rods in the premise of the effects supplied in this paper, subsequent conclusions were drawn;

- The studied anti-corrosive coating becomes the high-quality corrosion protection, eco-pleasant coating which does now no longer pollute the environment.
- Adhesions takes into account the excess adhesive energy gained for coatings GP9 to GP12. The geopolymerisation of the coating with clay cloth and rice husk ash with delivered Al_2O_3 has helped the coating for sturdy method of geopolymer coating. Therefore, the cause for excessive adhesive energy becomes the method of silate with the aid of using alumino silicate substances with the geopolymer binder.
- GP7, GP13, and GP16 rubbers failed using this tapered flex, take a look. The compositions of these types of 3 coatings are silicate wealthy coatings and the most effective Al2O3 is delivered. The richness of silicate in the composition supplied an inflexible formation of geopolymer. Therefore, those 3 coatings are failed in the ability to take a look at.
- The coating GP8 &GP13 located defects and all different coatings are handed in effect, take a look at.
- By all above take a look at the effects coatings, GP10, GP11, GP12, GP14, and GP15 carry out higher in all recognized together with mechanical and corrosion sturdiness take a look at.

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