RES MILITARIS
Social Science Journal

A comprehensive review on waste paper concrete.

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ABSTRACT

The constituents of concrete are cement, water, sand, and aggregate. Waste paper (WP) is mixed into a concrete mixture to create waste paper concrete (WPC). The output of WP gradually rises annually. The use of WP in concrete could reduce environmental pollutants. Thus, the potential of WP is reviewed in this extensive paper by replacing constituents of concrete at 0%, 5%, 10%, 15%, and 20%. The physical, chemical, and structural characteristics of WP are also reviewed in this work. This research also reviews the new, features of WPC, including slump, modulus of elasticity, stress-strain, and water absorption. Pursuant to this analysis, WP to concrete increases its fresh, structural, and durability qualities between 5% and 10%, and decreases it beyond 10%. The moist cement particles tend to strengthen the concrete more with 10% WP addition than they do at 5% WP addition. It appears that the addition of WP confers important and desired qualities above regular concrete, which is devoid of waste paper. WP's improved performance and qualities may make it a good candidate for use in the manufacturing of concrete.

Keywords *Waste paper, modulus of elasticity, water absorption*
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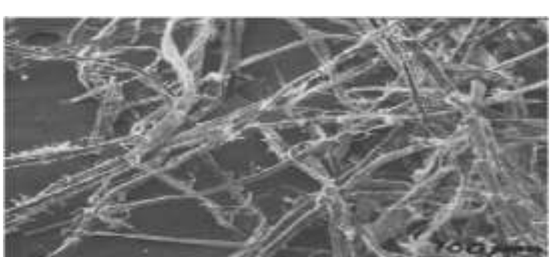
Introduction

Waste paper (WP) is mixed with concrete to make waste paper concrete (WPC), a novel composite material. These days, construction sites release carbon dioxide gas (CO2) as a result of the use of cement, which is a significant worry all. However, desire to live in an environmentally friendly setting is still growing. These problems are the focus of this investigation. Furthermore, excessive WP disposal may result in pollution of the environment. Using WP in the manufacturing of concrete helps to prevent and minimize environmental pollution. Because WPC is an environmentally beneficial building material that minimizes pollutants to arise, it also uses less cement, as indicated by Reference.[1]. This WPC is a long-lasting material for building and construction that is made by mixing WP with water and other ingredients, pouring the mixture into a mold, and drying it before it cures—either by air or water—before conducting experimental tests. Due to the fact that only specific percentages are permitted, This is because to the fact that larger WP percentages are inappropriate and could weaken the concrete, as mentioned by Ref. [2].that prior experimental findings demonstrate WPC's structural and financial viability in contrast to regular concrete, which is composed of cement, sand, water, and coarse aggregate but does not contain WP[3].Along from that, WPC might be a p rofitable substitute for incinerators, landfil ls, or other waste disposal techniques, as w ell as a reasonably priced commodity.[4]. Fiberglass material from WP is added to the mixed bulk to create lightweight concrete. It would be prudent to use WP structural concrete. It is a vital source of fiber and cellulose and one of the most common waste kinds in all disposal and landfill activity locations. As a result, by lowering WP disposal, a concrete mixture incorporating WP may be able to solve the landfill problem. Furthermore [5], observed that adding WP to concrete can reduce its density. The best approach to utilize Word Press effectively and wisely is to follow this Word Press integration. Thus, in order to assess the possibility of replacing current materials, its material properties WPC would offer a wide range of applications in civil and construction engineering as well as other benefits. Additionally, by using WPC in building construction making it stronger, and the quantity of steels used would decrease, cutting the costs of labor, energy, and materials. [6].in conclusion, the manufacturing WP recycling, especially in areas where it is not yet done. As a result, it conserves landfill space and lowers the amount of chemicals used in the processes involved in producing new paper. [7].this extensive review discusses the advantages of using WPC as well as the chemical and physical features of WP. According to this thorough analysis, the novelty is that adding WP at 5% and 10% improves the strength of the concrete. The cellulose microfibrils are malleable until they break apart from one another. Cellulose's chiral angle in the microfibrillar helix gives rise to an elastic modulus of 25 GPa. Micro fibril angles are more susceptible to natural variation than other angles, their mean values are closer to the fiber axis. Consequently, the modulus of elasticity of the fiber and cellulose characteristics is almost the same. [8,9]. The fibers in wood are chiral in almost all cases. The microscopic asymmetry image causes the twisting and chiral curl of WP fibers, as shown in Fig. 1.One of WP's main ingredients, wood celluloses, are fibrous materials that give the material more strength. It is composed of silica, calcium oxide, alumina and magnesium oxide elements.

Used paper properties

Burgess and Binnie (2010) [10] specific outcomes and discussions could be achieved through careful selection of test materials and methodologies. It was suggested that the characteristics of WP, such as humidity, temperature, radiation,

Table1



elements	Mg	K	Si	O_2	S	Ferum	Cl	Al
percentage	0.11	3.12	0.24	61.57	15.41	1.04	0.89	14.12

and pollution, need to be thoroughly examined.

Fig.1. Microscopic asymmetry image of WPfibres.

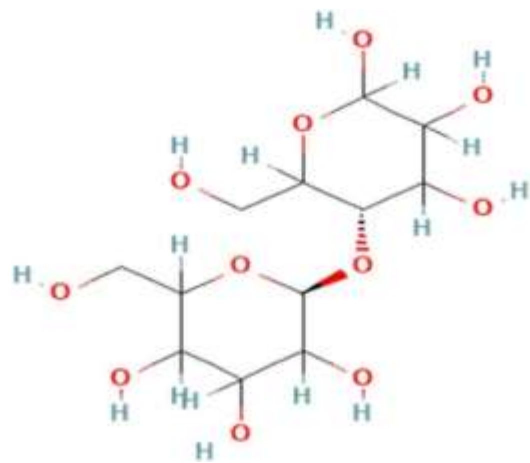


Fig.2. Elementsinacellulosefibre

Chemical properties

Lignin, a component separate from cellulose, exhibits heightened reactivity within specific particles. Paradoxically, the challenge lies in the difficulty of identifying and producing chemical probes, making WP the most challenging to monitor and quantify. Table 1 illustrates the chemical composition of WP.

Advantages of wastepaper concrete

They suggested that WPC could be used for non-load-bearing wall. Furthermore, because WPC had excellent sound absorption, it was considered a great choice for building materials in places like halls and auditoriums, where good sound performance is important.

WP chemical composition [11,12].

Table2

WP's grading [23].

Weightofpassing (%)	Sievesize(mm)
100	10.51
88	5.75
18	3.36
2	2.18
0	0.8

Fresh property of waste paper concrete

Slump

BalwaikandRaut(2011)[**1**3] The experiment involved testing concrete mixtures with varying percentages of WP (0%, 5%, 10%, 15%, and 20%) to partially replace OPC. Slump tests, as per IS 1199–1959, showed that as WP content increased more than five percent of cement, the slump value increased. However, above 5%, the slump value decreased. In concrete mixes labeled M —20 and M —30, the slump value increased from 69 mm to 71 mm and from 50 mm to 52 mm, respectively, with a 5% WP replacement. However, as the WP content increased further, the slump value decreased. To achieve the desired slump value with higher WP content, more water was needed. While adding more water could improve workability, it was suggested that an economical concrete mix could be achieved by carefully balancing water content with WP addition. As per, Ilakkiya and Dhanalakshmi (2018) [14] Zaki et al. (2018) the researchers examined the freshness of concrete by conducting slump tests with varying amounts of WP (0%, 5%, 10%, and 15%). They used a slump cone to measure how much the concrete slumped when lifted vertically and gradually after compaction, ensuring no shocks or vibrations during the test. Up to 10% WP added to the concrete increased the slump value, but adding more than 10% WP decreased the slump.

Specifically, adding 5% and 10% WP increased the slump from 75mm to 78mm and 80mm, respectively, compared to no WP. However, when 15% WP was added, the slump decreased from 80mm to 72mm. The percentage of super plasticizer used is dependent on the WP content. Density, requiring a extra amount of water or chemical additive. To maintain the slump value possible as well. Ramesh and Chandu (2018) [15]. As the findings obtained, the slump value increased by 48.06% with WPC 50%, while for WPC 100%, the slump value raised by 87.24% compared to the slump of conventional concrete. Fresh concrete had a higher slump value and more WP, which was substituted with coarse aggregate. The slump value increases with the amount of WP used to replace coarse aggregate. M—25 concrete behavior with a 0.45water-to cement ratio by substituting 0%, 5%, 10%, 15 %, and 20% WP for cement and conducting sl ump tests in accordance with IS1199–1959 for each concrete mixture.By employing WP in concrete, the WP disposal problem may occasi onally be resolved and concrete performance may be improved. A high concentration of sili con dioxide (SiO_2) in WP may also reinforce t he concrete.0.45.In M—25 concrete grade, a water-to cement ratio was used, increasing WP.Concret e workability was impacted by content by lowe ring the slump value recorded the highest slum p value at 5% cement replacement, and the slu mp value gradually dropped at higher replace ment percentages. Gallardo& Adajar (2006) [9] investigated the workability of concrete containing 0%, 5%, 10% and 15% of WP replacement with fine aggregate. The process of arriving at the precise ratio of cement, aggregate, and water to create concrete in accordance with the specifications was known as the concrete mix proportion. One reason for mix proportioning was to get a product that would play out the most fundamental prerequisites for the workability of fresh concrete. WP is an alternative material that was studied by observing its feasibility. The study's findings showed that concrete workability decreased when partial fine aggregate replacement with WP was greater than 10%, but increased when replacement was between 5% and 10% compared to 0%. Percentage replacement higher than 10% resulted in the slump value reduction. Silica helps in binding. The only long-term fix for this kind of problem was to add more water, even though doing so would weaken the concrete. The ASTM Type D/G super plasticizer was utilized in the concrete mixtures that contained WP. Its functions included increasing the strength and workability of the concrete Along with the addition of additive, the slump value of concrete containing WP dropped as the replacement % increased. WP could be used to concrete in place of certain fine aggregate to create affordable house.Based on research by Ravindra et al. (2015) [36], In four preliminary tests labeled T-1, T-2, T-3, and T-4, WP (waterproofing material) was gradually increased by 0%, 10%, 15%, and 20% in 25 concrete mixtures. WP, known for its high water absorption, required initial testing to find the right mix. The slump value, indicating workability, ranged between 70mm and 80mm but decreased as WP content increased. At water-to-cement ratios between 60% and 80%, the higher water absorption of WP weakened the bond between WP and cement paste.Asha et al. (2017) [38] The study examined replacing coarse aggregate with WP in Jung et al. (2015) [37] The study evaluated suitable replacements of cement mortar with WP at varying percentages: 0%, 5%, 10%, 15%, and 20% relative to the cement weight. Different mixing ratios mechanical and physical properties of the mortar.The results, as depicted in Table 7 and Figure 6 (showing slump value), illustrate changes in slump value with those using waste advertisement flyer and waste copying paper. This superiority was attributed to the high absorption rate of newspaper and the optimal composite of cement.

The study identified the optimum percentages of WP for achieving desired slump values. Additionally, it noted that a 5% replacement relative to cement weight yielded the highest compressive strength compared to 0%, 10%, and 15% concrete at varying volumes: 0%, 2.5%, 5%, 7.5%, 10%, and 12.5%. Concrete grades M20 and M25 were produced according to IS10262:2009 standard. The replacement of aggregates with WP fell within acceptable limits for both grades. Though not government-approved, these mixes could be utilized in construction and offer a cost-effective option for water proofing.

Mechanical properties of waste paper concrete

This section presents the mechanical properties of WP concrete

Compressive strength

Meanwhile, Selvaraj et al. (2015) [39] The study investigated the flexural strength of eight concrete mixes subjected to water curing for 7 and 28 days. These mixes comprised one control and seven variations with WP additions of 0%, 2.5%, 5%, 10%, 15%, 20%, 30%, and 35% by weight of ordinary Portland cement (OPC). The mix ratio was 1:1.5:2 (cement:sand:coarse aggregate), with a water-to-cement (W/C) ratio of 0.4.Results indicated that the demand for water in mixing increased with higher additions of WP, attributed to the cellulosic fiber materials causing increased water permeability characteristics. At 28 dayss

of water-to-cement (W/C) were explored alongside the impact on compressive strength based on the WP replacement ratio. Trials were conducted at W/C ratios of 45%, 60%, and 75% to assess both alterations in W/C ratio, replacement rate, and type of WP used. Mortar incorporating waste newspaper exhibited the highest compressive strength compared to replacements. This outcome was attributed to active hydration reactions facilitated by a smaller amount of WP replacement.

A significant increase in flexural strength was observed for all mixes except the control (0%), 2.5%, and 5% WP mixes. This increase was attributed to the contribution of cellulose fibers, which provided adequate bending stress and led to an increase in flexural strength. Additionally, flexural tests were conducted to evaluate high-strength concrete mixes with 20% and 40% replacement using 100% Recycled Coarse Aggregate (RCA).[40].Beam specimens of M25 grade concrete were prepared and subjected to testing at 7, 14, and 28 days of water curing. A suitable loading rate was applied, and specimens were tested to maximum stress until rupture, with fractures occurring on the tension surface within one-third of the mid-span.The results showed an improvement in flexural strength at 7, 14, and 28 days for concrete mixes containing 20% Recycled Coarse Aggregate (RCA) compared to the control (100% RCA) and mixes with 40% RCA. In summary, lightweight concrete could be achieved by replacing 20% of the concrete with RCA.All materials were added by weight relative to the respective mixes tested under the flexural test. Flexural strength was calculated based on parameters such as modulus of rupture, bend strength, and fracture strength.The results indicated that the flexural strength of concrete containing 20% RCA and 12% glass fiber surpassed that of the control concrete, marking it as the optimum level for achieving high flexural strength at 7, 14, and 28 days.The addition of glass fiber to the mix composition has been shown to increase the fracture energy of cement-based materials and reduce the self-weight of concrete.

In another study by Raghuwanshi et al. (2018), cement was replaced with WP in the range of 0%, 5%, 10%, 15%, and 20% by weight for the M25 mixture. Cylinders sized at 300 mm × 150 mm (diameter × height) were cast to conduct splitting tensile strength tests at 14 and 28 days following the IS5816-1999 standard. The load was applied to the upper surface of the specimen.The results indicated that 5% WP addition was the ideal mix proportion for achieving the highest splitting tensile strength. Furthermore, increasing the WP content beyond 5% resulted in a continuous reduction in strength for the M25 mixture at both 14 and 28 days.Besides the compressive and flexural strengths, Ilakkiya andDha- nalakshmi (2018) [33] The splitting tensile strength of the WP concrete was determined using cylindrical concrete specimens measuring 150 mm × 300 mm (diameter × height). These specimens were dried outdoors and placed on a steel jig with a balanced rate of loading ranging from 0.11 to 0.023 MPa/s following ASTM C496-90 standards.

During testing, two plywood sheets were positioned, one at the top and the other at the bottom of the specimen. The splitting tensile strength was found to be higher for the mix with 10% addition of WP compared to the reference mix. However, as the WP content increased beyond 10%, the splitting tensile strength gradually diminished.Overall, the splitting tensile strength exhibited an increase for the mix with 10% WP addition compared to the reference mix .he concrete mixtures containing 5%and 10% WP compared to the control mixture but reduced with 15% addition of WP.

Zaki et al. (2018) [21] Chung et al. (2015) also conducted a study on the splitting tensile strength of concrete containing varying percentages of WP (0%, 5%, 10%, 15%, and 20%). The test was conducted according to the ASTM C496-11 standard at 7, 28, and 56 days.

The results indicated that the splitting tensile strength of concrete mixtures containing WP was generally lower than that of the mixture without WP at all test stages. However, an exception was observed for concrete containing 5% and 10% addition of WP, which exhibited slightly higher splitting tensile strength than the mixture with 0% WP addition. Structural properties of wastepaper concrete.This section presents the structural properties of WP concrete, such as modulus of elasticity and stress-strain.

Modulus of elasticity

Seyyedalipouretal.(2014)[42] The structural properties of M25 and M40 concrete cylinders were determined by investigating the modulus of elasticity with varying percentages of cement replacement with WP: 0%, 10%, 20%, 30%, and 40%. The tests were conducted following IS10262:2009 standards with 56 days of water curing. The difference in modulus of elasticity was solely generated by the varying percentage replacements of WP, as the mix proportions of all different concretes remained constant.The utilization of WP in concrete mixtures, specifically M25 and M40, with 10% replacement, recorded a higher modulus of elasticity compared to conventional concrete mixtures without WP replacement (0% WP) after 56 days of water curing. However, the modulus of elasticity decreased with higher replacement percentages of WP, such as 20%, 30%, and 40%.

This research suggests that using WP in concrete mixtures not only saves disposal costs but also contributes to producing greener concrete. Even though WPC hasamixingdesignratio,itwasnotcertifiedfor use in residential buildings. Thus, two testing steps were conducted to determine the original mixing design ratio and the mechanical parameters of The study focused on investigating the properties of Wood-Polymer Composite (WPC), including its modulus of elasticity and failure mode. Initially, the paper-cement and sand-cement ratios were kept at 0.6 and 0.7, respectively, while varying water

-cement ratios from 1 to 16 to assess their impact.In the second stage of testing, the study aimed to determine the suitable mixing design ratio and mechanical properties by varying water-cement, paper-cement, and sand-cement ratio parameters. Chung et al. (2015) explained that changing the paper-cement ratio influenced the mechanical properties of WPC and was closely linked to the specimen's modulus of elasticity and failure mode.Multiple WPC specimens with different mixing design ratios were tested, revealing that the paper-cement ratio significantly affected the structural properties of WPC. Specifically, it was observed that as the paper-cement ratio increased, a ductile failure mode occurred, and the modulus of elasticity also increased..0%, 1%, 2.5%, 5%, 7.5% and 10% of WP replacing cement for preparation of M25 concrete cylinders.

Stress-strain

Shows The stress-strain curves of Wood-Polymer Composite (WPC) varied significantly based on different replacement contents of WP. Studies by Yun et al. (2011) and Seyyedalipour et al. (2014) showed that the ultimate strain ranges were 0.002–0.003, 0.005–0.007, and 0.008–0.010 when WP replacement contents were 5%, 10%, and 15%, respectively. Higher WP replacement contents led to higher ultimate strains in the stress-strain curves. Observations from the graphs indicated that the group with 10% WP replacement content (group PB) exhibited more ductility after the peak load compared to the group with 5% replacement content (group PA). Similarly, the group with 15% WP replacement content (group PC) was more ductile than group PB. The highest ductility was demonstrated by the 15% WP replacement content, followed by 10% and 5%.In conclusion, the stress-strain graph indicated that WPC, being a ductile material, could sustain large deformations. The study also examined cementations building products that utilized cellulose fibers recovered from wastewater paper recycling.

Discussions

WP in concrete aims to maintain low building costs while simultaneously minimizing pollution. Consequently, this method of WP usage stands out as an effective technique for disposal..(2018)[21] Zaki et al. explained that the decrease in concrete slump value is attributed to the high water absorption property of WP, particularly at higher percentages of WP content. Consequently, more water is required to achieve a comparable slump, and the addition of super plasticizer aids in improving the workability of concrete containing WP. However, increasing the WP content the high water absorption rate of WP poses a challenge to the workability of concrete mixes during experimental procedures. To address this issue, the addition of extra water is often considered a permanent solution. However, it's important to note that higher water content can lead to a reduction in concrete strength This super plasticizer plays a crucial role in enhancing concrete strength, workability, and reducing density, all while requiring less water content. Hence, WP can be effectively used in concrete production either through addition or partial replacement, whether with cement, sand, or aggregate.

Durability properties of waste paper concrete

This section presents the durability properties of WP concrete, focusing particularly on water absorption, carbonation, fire resistance, and efflorescence test results.

WP blend.

Four concrete mixes containing WP were made by Ghani and Mohammad Shukeri (2008) [14] in a weight-to-cement, sand, and aggregate ratio of 1:2:3. The controlled mixes included WP at weights of 0%, 5%, 10%, and 15% as supplementary material in the concrete. The increase in water absorption was influenced by the greater WP content. In comparison to the control combination, the water absorption rate for seven days was 13.9%–62.3%, and for twenty-eight days, it was 10.8%–118.4%.Malik's (2013) research [26] indicates that M—25 concrete compositions with 0%, 5%, 10%, 15%, and 20% of the cement replacement with WP underwent water absorption tests with a 0.45 w/c ratio after 28 days. The cube specimens were taken out of the mold, and their weight was recorded at 28 days after they had been fully submerged in water for 28 days. The average dry weight was also recorded. Every concrete cube specimen provided an indirect measure of durability in addition to the percentage of water absorption. With fly ash levels of5%,10%, and 15%, the water absorption percentage rose. The waste absorption value was lowest at 5% WP content and highest at 15% WP content.

M—25 concrete grade was made up of four concrete mixtures that included 0%, 10%, 15%, and 20% WPA as extra material. Ravindra et al. (2015) prepared the concrete[36].The water absorption rate of concrete decreases with increasing WP content, as Fig. 8.12.93%–13.34% illustrates. 28 days. The consistently

Water absorption

The water absorption characteristics of 100 mm concrete cubes on all sides were examined, incorporating WP at levels of 0%, 5%, 10%, 15%, and 20% by weight of cement. The test adhered to ASTM C642-13 standards. The presence of WP in the concrete mixtures resulted in increased water absorption and decreased density, except for the mix containing 5% WP

reduced percentages of concrete water absorption with 10%, 15%, and 20% WP addition were 0.1%, 0.2%, and 0.4% as compared to 0%.

In order to determine whether waste newspaper and office paper (WPC) is a suitable material to use in building construction, measured the water absorption capacity of each concrete mixture in the following ratios: 1:1:0.2, 1:1:0.4, 1:1:0.6, and 1:1:0.8 for cement: sand:WP. adding more WP content will concrete. Apart from the 60% newspaper-to-cement ratio, WPC composed of newsprint often absorbed more water than WPC composed of office paper. Newspapers absorb more water than office paper because of their lower gram mage (grams per square meter). Newspaper absorbs more water because the cellulose fiber's inter-fiber connection is easier to get loosened and weakened. When compared to office paper, WPC had better structural qualities constructed of newspaper. However, due to its high water absorption capacity, WPC, which is composed of newspaper and office paper, should not be used for external or near-ground walls. The WPC samples were made using wet pulp in the form of fibrous cement. There were twelve samples in all, 10 of which were cement mix samples and varying WP percentages .The rest were cement and WP alone, with no additional WP.0.4w/cratios were applied to every sample. For the water absorption test, office paper was utilized. The length of the immersion enhanced water absorption. which was influenced by the cellulose material and void volume supplied, may be the cause of the high concentration of

WP.In order to investigate the durability quality of WPC cubes, Selvakumar et al. (2018) [51] conducted water absorption experiments at 14 and 28 days with 0%, 10%, 20%, and 30% of WP addition by weight of cement. The ratio of cement to sand to coarse aggregate was 1:3:6.The water absorption value of WPC was found to be highest at 30% of the cement weight, and the lowest at 0% of the addition. Therefore, during both 14 and 28 days, the optimal water absorption values were obtained with a 10% addition of WP by weight of cement. Water absorption experiments were conducted at 7, 14, and 28 days to examine the durability quality of concrete with 0%, 5%, 10%, 15%, 20%, 25%, and 30% of WP added [52]. Concrete absorbs more water when it cures for a longer time

Table9 Optimum percentages of WP for water absorption.

References	Percentage/ratioofWP(%)	Optimumpercentages/ratios(%)
Balwaik&Raut(2011)	0%,5%,10%,15%,20%ofWPas	20%
[32]	partialreplacementofcement	
Zakietal.(2018)[21]	0%,5%,10%,15%,20%ofWPas	20%
	partialadditionbyweightof	
	cement	
Ghani&Mohammad	0%,5%,10%,15%additionofWP	15%
Shukeri(2008)[14]		
Malik(2013)[26]	0%,5%,10%,15%,20%as partial	20%
	cementreplacementwithWP	
Ravindraetal.(2015)	0%,10%, 15%,20%of WPas	0%
[36]	addition	
Akinwumietal.(2014)	cement:sand:WP=1:1:0,1:1:0.2,	1:1:0.8
[48]	1:1:0.4,1:1:0.6,1:1:0.8	
Salem&Al-Salami	0%,50%,83.3%additionofWP	83.3%
(2016)[50]		
Selvakumaretal.	0%,10%,20%,30%ofWP	30%
(2018)[51]	additionbyweightofcement	
Tantray(2019)[52]	0%,5%,10%,15%,20%,25%,	30%
	30%additionofWP	

The efflorescence test is used to detect the presence of soluble salt deposits near the surface of porous materials when they come into contact with water. It helps categorize the condition of Wood Plastic Composite (WPC) into five levels based on the amount of efflorescence observed: no efflorescence, minimal efflorescence, moderate efflorescence, heavy efflorescence, and severe efflorescence. The test is conducted after curing the samples for 28 days. Data from the efflorescence test for different replacement percentages are outlined in... Figure 10.In the control concrete brick, as well as in cases where 20% and 30% of WP replacement was applied, a small film of less than 10% salts was observed. However, for 40% WP replacement, the condition was moderate in terms of salt deposition on the concrete brick surface area.

Conclusion

In conclusion, numerous previous studies have been conducted on Wood-Polymer Composite (WPC), revealing its significant advantages compared to ordinary concrete lacking WP content. It is evident that WP possesses favorable properties with the potential for enhancing concrete characteristics. Research suggests that replacing 4%–10% of cement with WP, or adding 4%–10% WP to concrete, enhances fresh and mechanical properties such as resistance against compressive force, flexural strength, and counter force against tension, as demonstrated by numerous experimental investigations. Concluded that the higher the paper-cement ratio, the higher the stress- strain and ultimate strain values, except for 15% WP addition or replacement .Same for carbonation, fire resistance and efflorescence test results. The results increase with the inclusion of WP at 5% and 10%. WP in concrete production is warranted and technically feasible, although considerations shall be taken to ensure adequate performance.

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