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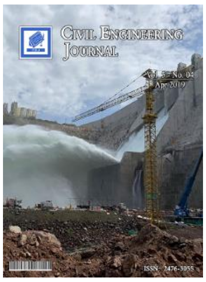

Effect of Hospital Effluents and Sludge Wastewater on Foundations Produced from Different Types of Concrete

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Abstract

In last decades, there is an insufficiency of fresh water and construction works are increasing day by day consuming large amount of fresh water. Therefore research is processing on to employ the treated domestic wastewater in the preparation and curing of concrete. In this investigation, the concrete slab specimens casted with normal strength concrete and modified reactive powder concrete. The concrete specimens cast by using fresh water, wastewater, and hospital effluents water. The specimens cured in all water types for 28days and 56 days. At 28days curing with wastewater, a decrease in punching shear strength was observed from 24 kN in case of curing with fresh water to 21 kN and 20 kN in case of curing with wastewater and hospital effluents water respectively. Highest strength is exhibited by 56 days curing age, it was recorded about 32 kN, 24 kN and 23 kN punching shear strength of specimens cured with fresh water, wastewater and hospital effluents water respectively. The excess quantity of bicarbonates in treated domestic wastewater as curing water results a decrease in compressive strength of concrete specimens. Appearance of first crack was also affected significantly by using wastewater and hospital effluents water as curing water; 7.5 kN, 6.5 kN and 6 kN were the first crack loads of normal strength concrete panels cured with fresh water, wastewater and hospital effluents water, and 11 kN, 10 kN and 7.5 kN were the first crack loads of modified reactive powder concrete cured with fresh water, wastewater and hospital effluents water.

Keywords: Slab; Fresh Water; Wastewater; Hospital Effluents Water; Punching Shear Strength; First Crack Load.

1. Introduction

Concrete is one of the most important construction materials in most countries of the world. This material is usually made from mixing the gravel, sand, cement and water. The amount of aggregate is about 70% of normal concrete components, while a cement and water represent 20% and 10% respectively of concrete components. The amount of water used in the concrete industry is about 1 billion tons in the world, in addition to the large amount of water used in concrete curing. Therefore, the concrete industry is an important factor affecting the environment through water consumption. So, it is necessary to find other resources of water to compensate the quantities industry. Impurities in water used for mixing concrete, when excessive, may affect not only the concrete strength but also setting time and may cause efflorescence staining. Therefore, a specific specifications should be adopted to clarify the limits of sulfates, alkalis, chlorides and solids in curing and mixing of concrete, in addition to perform different tests to notify the properties of water [1].

The impact of wastewater on the durability of concrete cannot be omitted. According to ACI committee 201 [2] , the durability of concrete is the ability to resist the chemical attack , weathering condition and abrasion or any other conditions causing concrete deterioration [3]. The durable concrete keep its serviceability and quality when exposed to environmental conditions.

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Although the concrete is considered durable when exposed to environmental conditions, it suffers from deterioration in waste treatment plants structures [4]. The type of wastewater and its components depends on the source from which this water is brought, each type of water causes an effect different from the other.The major contributor factor that may cause a deterioration of concrete structures is the bacterial manifestation of Thiobacillustype. The cohesion and loss of strength may achieve as a result of the product of sulfuric acid with the metabolism, this product may attack the cement matrix of concrete [5, 6].

Tilly et al. (2008) [7] defined the wastewater as a combination of black water (faucal sludge, urine and excreta) and a grey water (bathing wastewater and kitchen wastewater. The water from commercial and institution building, like (industrial effluents, urban run-off, storm water, hospital, agricultural and aquaculture effluents) may be dissolved or suspended. The nature of wastewater is greatly affected by anthropogenic impact [8]. Several studies were carried out on concrete specimens to investigate the corrosion mechanism and concrete deterioration. Mori et al. [9] made on experimental study on cement mortar having dimensions $(40 \times 40 \times 160)$ mm and exposed to H2S gas not exceeding 300 ppm. The specimens appeared a significant corrosion in its surface vice versa the specimen treated with pure water. Moteny et al. [10] developed concrete specimens having dimensions $(600 \times 1100 \times 70)$ mm sprayed with H2S gas at 10 ppm. It was found that the amount of corrosion depends mainly on the level of Thiobacillus Thiooxidans detected.

The effect of Tio2 particles on mechanical properties was studied by Nazari and Riahi (2010) [11]. Due to the effect of Tio2 in increasing the crystalline of calcium dioxide at early stage of hydration, the concrete compressive strength was increased, the Tio2 worked as antibacterial agent. Other types of concrete were studied such that fly ash and slug under the effect of adding Tio2, the mechanical properties of concrete was significantly improved due to adding the Tio2, adding Tio2 on these types effectively contributes to increase the strength at early and advanced stages of hydration [12]. The effect of bacterial attack can be significantly seen in tanks, bridges, dams, cooling towers, harbors and building foundations in contact to bacterial agent such that sewer pipes and polluted rivers. The pores and cracks help the polluted water to flow inside the concrete, in addition to corrosion of concrete surface [13]. The concrete chemical and physical properties of course will be affected due to the biological factors; it should be taking in to consideration the heterogeneity of concrete which composed of cement, sand and gravel [14]. The corrosion of concrete is achieved by presence of biogenic hydrogen sulfide and sulfuric acid in polluted water and sewage [15, 16].

Fuad and Romilde (2011) [17] studies the sulfate attack on foundation elements of buildings, this study involved the water components, compressive strength of concrete, cement type, water to cement ratio (w/c) and soil drainage on structure of building Ericka in Brazil. By X-ray diffraction, this study revealed that the sulfate resistance cement and w/c ratio contribute to reduce the sulfate attack in concrete. Furthermore, the compressive strength was changed in comparison with that at beginning of construction.

In many countries, hospital wastewater is throw out in the rivers, and when the water flows through the soil in the areas close the river, it may cause a damage in the foundations of buildings. In addition, due to broken sewage pipes the wastewater may flow through the soil to the foundation. The authors believe that this study is one of early research to evaluate the behavior of concrete foundations exposed to hospital wastewater and sewer water.

2. Materials and Methods

2.1. Instrumentation and Test Method

As shown in Figure 1 the punching load was applied through a hydraulic compression machine have 3000 kN capacity the load was applied at the panel center with an increments 2.5 kN. A dial gauge with an accuracy 0.01 mm was used to measure the deflection at panel center, see Figure 2.

Figure 1. Test set up

Figure 2. Position of dial gauge

2.2. Mix Design

In order to study the effect of treated domestic wastewater on the fresh and hardened state properties of concrete. Two types of concrete; normal strength concrete and modified reactive powder concrete were selected for the study. Mix design was carried out as per (ACI 211.1-91 2009) [18]. Table 1 illustrates the mix proportion for each type of concrete.

Table 1. Mix proportions

Mix type		Normal strength concrete	Modified reactive powder concrete
Compressive Strength		27.2 MPa	63.5 MPa
w/c ratio		0.44	0.3
Mix Proportions (kg/m^3)	Water	183	252
	Cement	415	843
	Sand	535	1029
	Gravel	1250	109
	Silica Fume	---	211
	Superplasticizer	---	12.7
	Steel Fiber	---	187

2.3. Curing

The concrete slabs were poured according to the mix design components. For normal concrete specimens, three different combination of curing water were performed as mentioned below.

- Specimens were cured using 100% laboratory tap water.
- Specimens were cured using 100% wastewater.
- Specimens were cured using 100% hospital effluents water.

2.4. Materials

General description and specifications of materials used in the test are listed below:

2.4.1. Cement

The cement type that used in this investigation is ordinary Portland cement OPD (Type 1) to avoid atmospheric conditions, the cement was kept in a dry conditions. The chemical and physical analysis of the cement is mentioned in Tables 2 and 3 respectively. They conform to (ASTM C-150-2015) [19].

Table 2. Chemical composition of cement

Chemical Composition	Percentage by Weight
SIO2	22.7
AL2O3	6.12
FE2O3	4.25
CAO	62.31
MGO	2.98
SO3	1.92
I.O.I	2.95
I.R	0.95
CA3	1.97

Table 3. Physical properties of cement

Physical Properties	Test result
Fineness m^2/kg	3100
Soundness	0.19 %
Setting time using Vicat's instrument	
Initial setting time (min.)	198
Final setting time (hrs: min)	4.5
Paste compressive strength of cement cube 70.7x70.7 mm at:	
Three days (MPa)	19.4
Seven days (MPa)	29.75
28 days (MPa)	48.33

2.4.2. Fine Aggregate

Fine aggregate used in this study, has a maximum size less than (5 mm) and brought from natural source. The grading of the fine aggregate is shown in Table 4 and Figure 3; which conforms to the British Standards (BS 882-1992) [20].

Table 4. Grading of fine aggregate

No.	Sieve size (mm)	Present work fine aggregate (% passing)
1	5.0	90.52
2	2.36	80.10
3	1.180	67.72
4	0.60	44.64
5	0.30	7.09
6	0.15	3.43

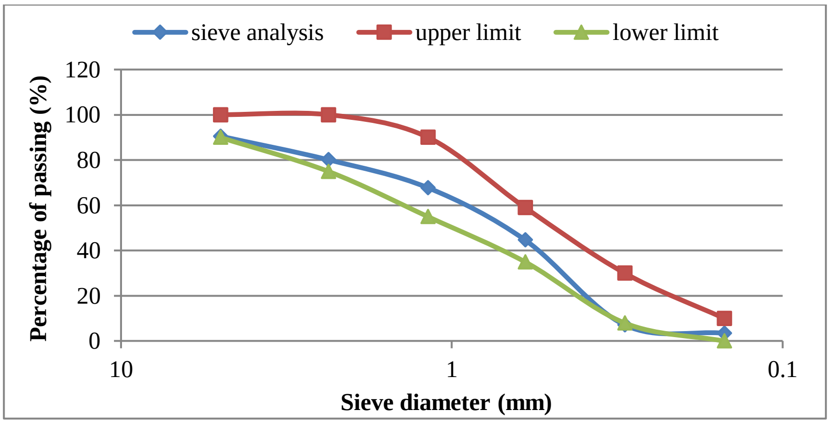

Figure 3. Grading of fine aggregate

2.4.3. Coarse Aggregate

The ideal coarse aggregate should be clean. 100% crushed aggregate with a minimum of flat and elongated particles is used. Coarse aggregate is brought from natural source. Table 5and Figure 4 show the grading of the coarse aggregate, which conforms to the British Standards (BS 882-1992) [20].

Table 5. Grading of coarse aggregate

No.	Sieve Size (mm)	Present Work of Coarse Aggregate (% Passing)
1	20	100
2	14	100
3	10	74.5
4	5.0	1.23
5	2.36	0

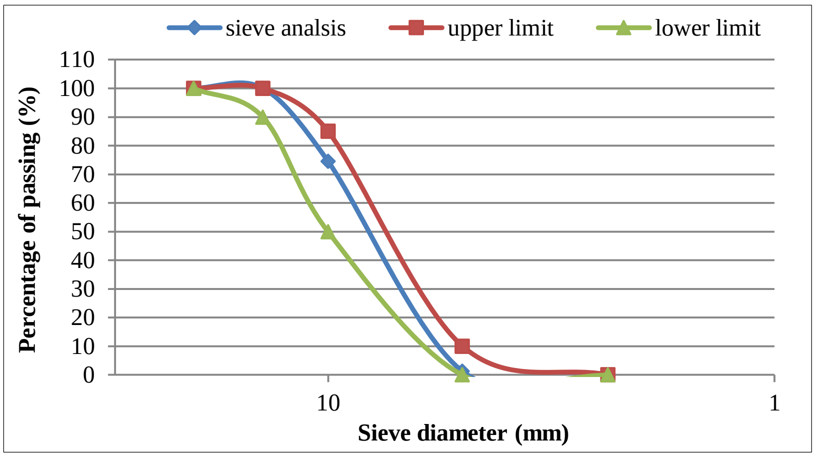

Figure 4. Grading of coarse aggregate

2.4.4. Admixtures

In order to produce modified reactive powder concrete mixes, Glenium51 is the most commonly used in concrete industries. Table 6 shows typical properties of Glenium51.

Table 6. Specifications of superplasticizer (Glenium 51)*

No.	Main action	Concrete super plasticizer
1	Color	Light brown
2	pH. Value	6.6
3	Form	Viscous liquid
4	Chlorides	Free of chlorides
5	Relative density	1.08 – 1.15 gm/cm3 @ 25°C
6	Viscosity	128 ± 30 cps @ 20°C
7	Transport	Not classified as dangerous
8	Labeling	No hazard label required

* Supplied by the manufacturer.

2.4.5. Steel Fibers

Through this experimental work, Hooked ends steel fibers were used with volume fractions (Vf= 1.0%) of concrete volume. The steel fiber properties are illustrated in Table 7.

Table 7. Properties of the steel fibers*

Property	Specifications
Relative Density	7860 kg/m^3
Yield strength	1130 MPa
Modulus of Elasticity	200×103 MPa
Strain at Portion limit	5650×10^{-6}
Poisson's ratio	0.28
Average length	50 mm
Nominal diameter	0.5 mm
Aspect ratio	100

* Supplied by the manufacturer

3. Results and Discussions

3.1. Load – Displacement Responses

Figures 5 to 10 show the load-deflection behavior of all slabs. In general, the load-deflection behavior of tested specimens can be divided into two stages. The stage one is called "pre-cracking stage", in which, the load-deflection behavior of all tested specimens was approximately linear, it is extend from start of loading until appearance of first crack, it is evident that cracking point for all specimens is different according to the state and period of submergence. The first flexural cracks of normal strength concrete with submergence period 28 days and 56 days in fresh water were

(7.5 kN) and (10 kN) respectively. On the other hand when submerging the normal concrete specimens in hospital water, the first flexural cracks were initiated at (6 kN) and (7 kN) respectively. Moreover, the first flexural cracks in case of submergence the normal strength concrete slab in wastewater for 28 days and 56 days were recorded at (6.5 kN) and (7 kN). In modified reactive powder concrete specimens; at 28 day, the specimens recorded first crack load at (11 kN), (7.5 kN) and (10 kN) when submerged in fresh water, hospital water and wastewater respectively. While at 56 days of submergence, the specimens recorded first crack appearance at (12.5 kN), (10 kN) and (11.5kN) when submerged in fresh water, hospital water and wastewater respectively. In second stage called (post-cracking stage), new cracks were initiated then developed to slab edges, which lead to a reduction of stiffness of the specimens, and appeared a different behavior of the slabs. At a same load value, the deflections of fresh water cured slabs is lower than the one of slabs cured with wastewater and hospital effluents. It means that, wastewater and hospital effluents water contribute to decrease the stiffness of slabs and this decrease is directly proportional to days of curing used in slabs. Also, the specimens with 56 submergence days have deflections less than the specimens with 28 day submergence period even in specimens that were submerged in hospital water and wastewater, this means that the hydration process was continued used fresh water particles in hospital water and wastewater.

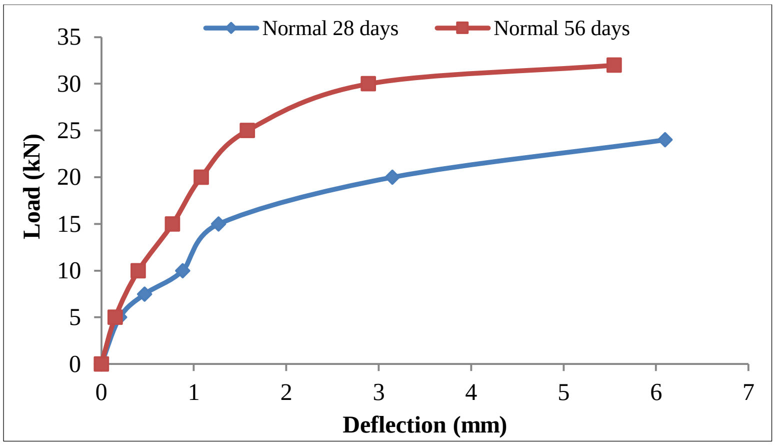

Figure 5. The relationship between Load and deflection of normal concrete-fresh water

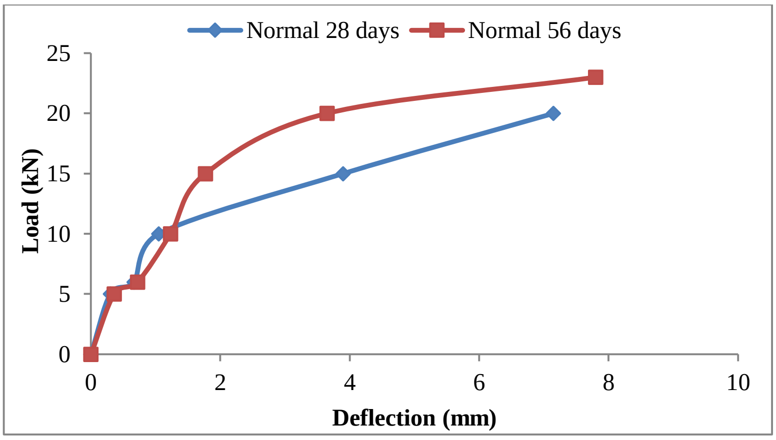

Figure 6. The relationship between load and deflection of normal concrete-hospital water

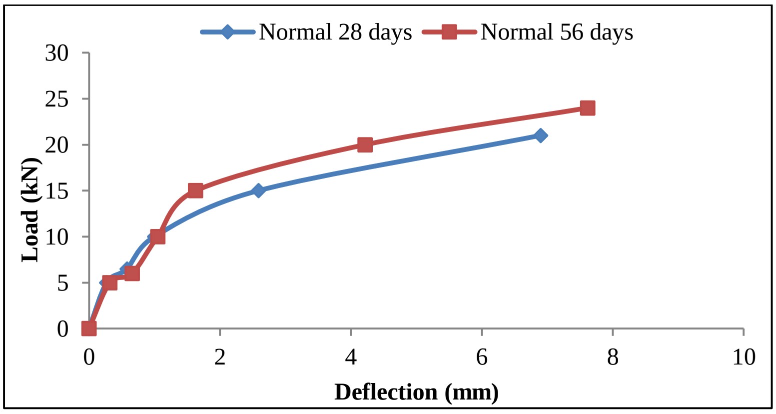

Figure 7. The relationship between load and deflection of normal concrete –wastewater

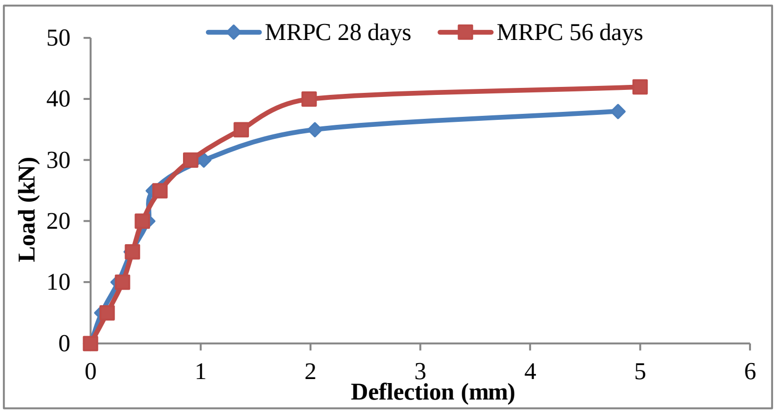

Figure 8. The relationship between load and deflection of MRPC -fresh water

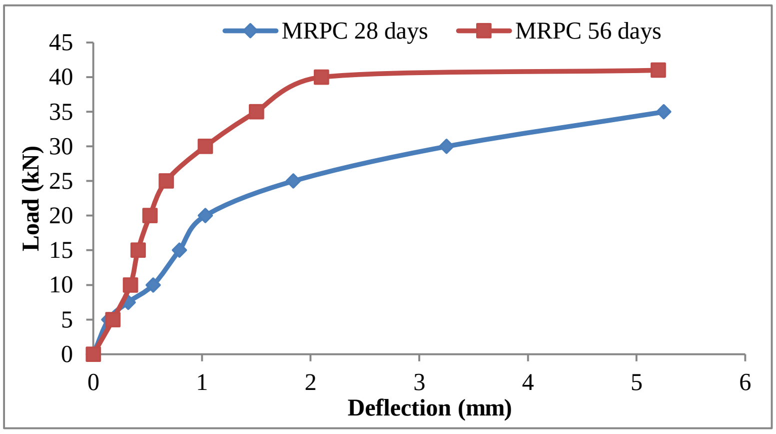

Figure 9. The relationship between load and deflection of MRPC –hospital water

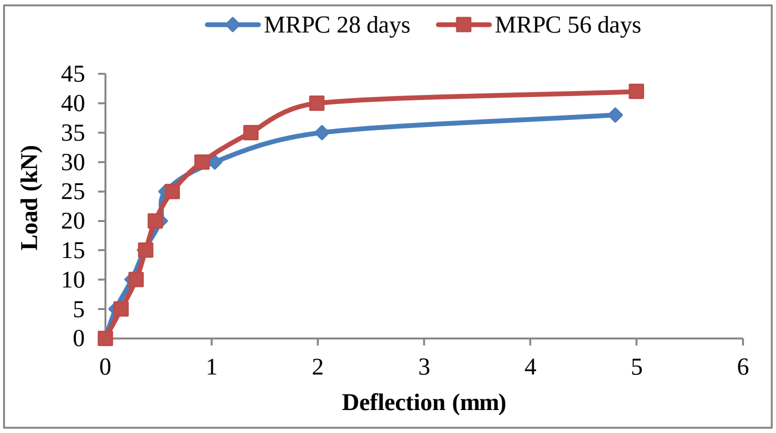

Figure 10. The relationship between load and deflection of MRPC –wastewater

3.2. Behavior of the Specimens

The typical response observed can be divided into four distinct stages as illustrated in Figures 11 to 22. Upon loading, the center of the specimen moved downward and the edges of the specimen started to rotate and translate in the plane of the slab. During this stage, specimen remained un-cracked and the applied load increased linearly with the deflection (Stage I). Stage II, the slab stiffness gradually reduced as the applied load increased. At the same time, an increase in the bars forces was observed indicating that the slab was expanding laterally. The amount of force increase was governed by the axial stiffness of the bars which was constant for all specimens. In Stage III, a deformation increase took place without any significant increase in the vertical load. During this stage, the bar forces increased at a lesser rate, and reached a maximum value at the end of this stage. The post-peak stage (Stage IV) indicated further reduction in the load-carrying capacity. This reduction occurred in several steps, with spreading of cracks on the tension surface. In this stage, the bars forces decreased considerably, returning approximately to the values recorded at the beginning of the test. In general, the behaviour of the specimens was similar for all specimens except the specimens with wastewater curing and hospital effluents water curing; the failure rate was faster than the specimen with fresh water curing.

Figure 11. Failure form of slab (SNF1)

Figure 12. Failure form of slab (SNF2)

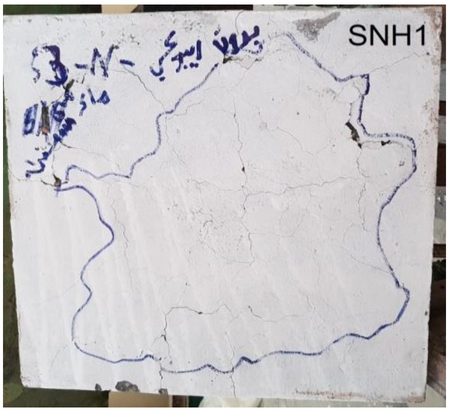

Figure 13. Failure form of slab (SNH1)

Figure 14. Failure form of slab (SNH2)

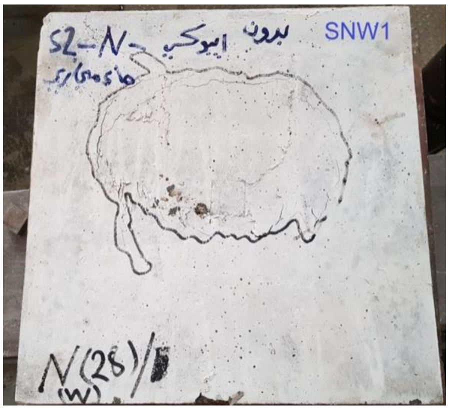

Figure 15. Failure form of slab (SNW1)

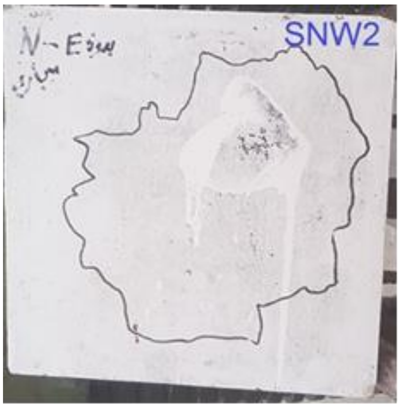

Figure 16. Failure form of slab (SNW2)

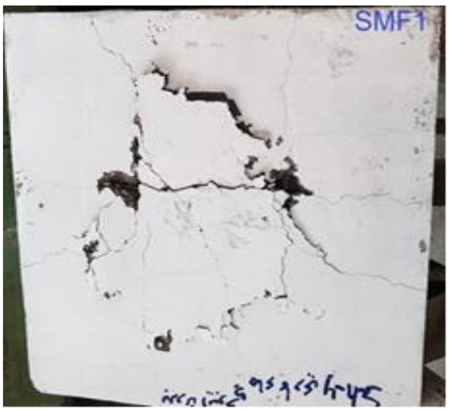

Figure 17. Failure form of slab (SMF1)

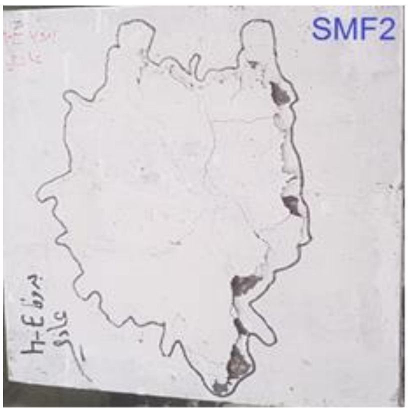

Figure 18. Failure form of slab (SMF2)

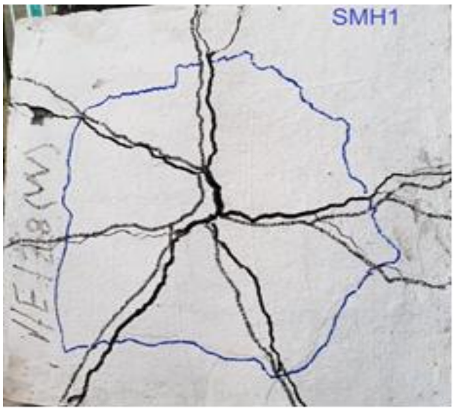

Figure 19. Failure form of slab (SMH1)

Figure 20. Failure form of slab (SMH2)

Figure 21. Failure form of slab (SMW1)

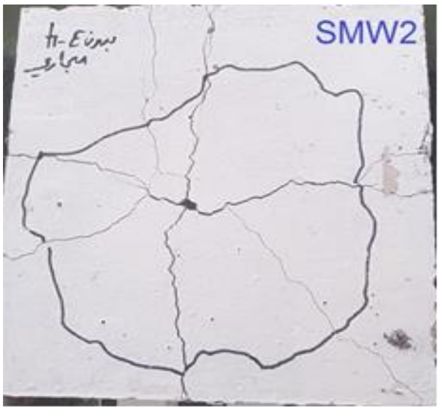

Figure 22. Failure form of slab (SMW2)

Where:

SNF1: slab of normal concrete, with fresh water, at 28 days

SNF2: slab of normal concrete, with fresh water, at 56 days

SNH1: slab of normal concrete, with hospital water, at 28 days

SNH2: slab of normal concrete, with hospital water, at 56 days

SNW1: slab of normal concrete, with wastewater, at 28 days

SNW2: slab of normal concrete, with wastewater, at 56 days

SMF1: slab of modified reactive concrete, with fresh water, at 28 days

SMF2: slab of modified reactive concrete, with fresh water, at 56days

SMH1: slab of modified reactive concrete, with hospital water, at 28 days

SMH2: slab of modified reactive concrete, with hospital water, at 56 days

SMW1: slab of modified reactive concrete, with wastewater, at 28 days

SMW2: slab of modified reactive concrete, with wastewater, at 56 days

3.3. Failure Loads of Specimens

Through an extensive comparison between the specimens cured with fresh water and other specimens, it can be concluded that the specimens cured with fresh water have failure load more than other specimens with wastewater and hospital effluents curing water. In case of normal strength concrete panels, at 28 days of curing, the specimens achieved ultimate strength about 24 kN, 21 kN and 20 kN for curing in fresh water, wastewater and hospital effluents water respectively. While, modified reactive powder concrete slabs achieved ultimate strength about 42.5 kN, 38 kN and 35 kN for curing in fresh water, wastewater and hospital effluents water respectively. It is clear that types of curing water slightly effect on the punching shear strength at the first month of curing. But the amount of reduction in punching shear strength appeared more significant at the second month of curing; the ultimate strength about 32 kN, 24 kN and 23 kN for curing in fresh water, wastewater and hospital effluents water respectively for normal strength concrete panels, and the ultimate strength about 53 kN, 42 kN and 41 kN for curing in fresh water, wastewater and hospital effluents water respectively for modified reactive powder concrete panels.

For normal strength concrete slab, there is an increase in punching shear strength about 33.3% due to submergence the slab specimen for 56 days in fresh water in comparison with specimen that submerged 28 days in fresh water. While, 56 days of submergence in wastewater increased the punching shear strength about 14.28% higher than the specimen that submerged 28 days in wastewater. On the other hand, the specimen that were submerged 56 days in hospital effluents water recorded about 15% increase in punching shear strength from specimen that were submerged for 28 days.

As for MRPC, submerging it in different water types for 56 days contributes to increase the punching shear resistance by about 24.7 %, 10.5 % and 17.14 % for specimens submerged in fresh water, wastewater and hospital effluents water respectively in comparison with its strength at 28 days, see Table 8.

Using wastewater and hospital effluents in curing the specimens reduced the ultimate load capacity and stiffness. Decreasing in the ultimate load and stiffness can be attributed to the decrease in compressive membrane action which, in turn, was affected by the level of stress.

3.4. First Crack Loads of Specimens

In case of fresh water cured specimens, the first crack load of slab specimens is more than the wastewater and hospital effluents water cured specimens, in normal strength concrete slabs (SNF1) and (SNW1) and (SNH1) with (7.5 kN), (6.5 kN) and (6 kN) cracking load with 28 curing days. The first crack load of wastewater and hospital effluents water cured specimens of modified reactive powder concrete slabs is less than the original beams, in slabs (SMF1) and (SMW1) and (SMH1) with (11 kN), (10 kN) and (7.5 kN) respectively, this difference belong to the difference between the compressive strength of concrete and the lack of bond between concrete and reinforcing bars.

For normal strength concrete slab, there is an improvement in first crack load about 33.3% due to submergence the slab specimen for 56 days in fresh water in comparison with specimen that submerged 28 days in fresh water. While, 56 days of submergence in wastewater improved the first crack load about 7.7 % higher than the specimen that submerged 28 days in wastewater. On the other hand, the specimen that were submerged 56 days in hospital effluents water recorded about 16.6% increase in first crack load from specimen that were submerged for 28 days.

As for MRPC, submerging it in different water types for 56 days contributes to increase the first crack load by about 13.63 %, 15 % and 33.3 % for specimens submerged in fresh water, wastewater and hospital effluents water respectively in comparison with its strength at 28 days, see Table 8.

Table 8. Ultimate load and first crack load of tested slab

Specimens Symbols	Type of water	Submergence period (days)	Pu (kN)	Improvement (%)	Pcr (kN)	Improvement (%)
Normal Concrete Specimens						
SNF1	Fresh water	28	24	R*	7.5	R*
SNF2	Fresh water	56	32	33.3	10	33.3
SNW1	Wastewater	28	21	R*	6.5	R*
SNW2	Wastewater	56	24	14.28	7	7.7
SNH1	Hospital effluents water	28	20	R*	6	R*
SNH2	Hospital effluents water	56	23	15	7	16.6
Modified Reactive Powder Concrete Specimens						
SMF1	Fresh water	28	42.5	R*	11	R*
SMF2	Fresh water	56	53	24.7	12.5	13.63
SMW1	Wastewater	28	38	R*	10	R*
SMW2	Wastewater	56	42	10.5	11.5	15
SMH1	Hospital effluents water	28	35	R*	7.5	R*
SMH2	Hospital effluents water	56	41	17.14	10	33.3

R*: is the reference slab specimen

3.5. Stiffness of Tested Specimens

In case of normal strength concrete slab panels, the stiffness of fresh water cured specimens appeared higher than other specimens that cured with wastewater and hospital effluents water. Specimen (SNF1) (cured with fresh water) achieved flexural stiffness about 3.93 kN/mm. while the flexural stiffness of specimens cured with wastewater (SNW1) and hospital effluents (SNH1) achieved flexural stiffness about 3.04 kN/mm and 2.78 kN/mm respectively. On the other hand, modified reactive powder concrete slab panels similar normal strength concrete in term of lack of stiffness due to use wastewater and hospital effluents water; 11.03 kN/mm, 7.24 kN/mm and 7 kN/mm, the flexural stiffness's of slabs cured by fresh water, wastewater and hospital effluents water respectively.

For normal strength concrete slab, there is an increase in the stiffness of tested specimens by about 46.56% due to submergence the slab specimen for 56 days in fresh water in comparison with specimen that submerged 28 days in fresh water. While, 56 days of submergence in wastewater improved the stiffness of tested specimens about 3.6 % higher than the specimen that submerged 28 days in wastewater. On the other hand, the specimen that were submerged 56 days in hospital effluents water recorded about 5.75% increase in stiffness from specimen that were submerged for 28 days.

The considerable improvement in stiffness can be seen obviously when submerging the modified reactive powder concrete specimens for 56 days in different types of water. In specimen (SMF1) (with 28 days fresh water curing) have a flexural stiffness about (k=11.03 kN/mm), the specimen (SMF2) (with 56 days fresh water curing) improved the flexural stiffness about (6.7%) over reference specimen (SMF1). In specimen (SMW1) (with 28 days fresh water curing) have a flexural stiffness about (k=7.24 kN/mm), the specimen (SMW2) (with 56 days fresh water curing) improved the flexural stiffness about (93.37%) over reference specimen (SMW1). Accordingly, the specimen (SMH2) (with 56 days fresh water curing) improved the flexural stiffness about (12.57%) over reference specimen (SMH1), see Table 9.

Table 9. Stiffness of tested slab

Specimens Symbols	Pu (kN)	Δu (mm)	Stiffness = Pu/ Δu (kN/mm)	Improvement (%)
SNF1	24	6.1	3.93	R*
SNF2	32	5.55	5.76	46.56
SNW1	21	6.9	3.04	R*
SNW2	24	7.62	3.15	3.6
SNH1	20	7.15	2.78	R*
SNH2	23	7.8	2.94	5.75
SMF1	42.5	3.85	11.03	R*
SMF2	53	4.5	11.77	6.7
SMW1	38	5.25	7.24	R*
SMW2	42	3	14	93.37
SMH1	35	5	7	R*
SMH2	41	5.2	7.88	12.57

R*: is the reference slab specimen

3.6. Energy Absorption of Tested Specimens

Table 10 shown the energy absorption of tested slabs due to use fresh water, wastewater and hospital effluents water in curing. In case of normal strength concrete slab panels, the energy absorption of fresh water cured specimens appeared higher than other specimens that cured with wastewater and hospital effluents water. Specimen (SNF1) (cured with fresh water) achieved energy absorption about 102.7 kN.mm. While the energy absorption of specimens cured with wastewater (SNW1) and hospital effluents (SNH1) achieved energy absorption about 114.83kN.mm and 126.58kN.mm respectively. On the other hand, modified reactive powder concrete slab panels similar normal strength concrete in term of increase the energy absorption due to use wastewater and hospital effluents water; 121.83kN.mm, 143.6kN.mm and 147.7 kN/mm, the energy absorption of slabs cured by fresh water, wastewater and hospital effluents water respectively.

For normal strength concrete slab, there is an increase in the energy absorption of tested specimens by about 42.4% due to submergence the slab specimen for 56 days in fresh water in comparison with specimen that submerged 28 days in fresh water. While, 56 days of submergence in wastewater improved the energy absorption of tested specimens about 15.68 % higher than the specimen that submerged 28 days in wastewater. On the other hand, the specimen that were submerged 56 days in hospital effluents water recorded about 7.3% increase in energy absorption from specimen that were submerged for 28 days.

The considerable improvement in energy absorption can be seen obviously when submerging the modified reactive powder concrete specimens for 56 days in different types of water. In specimen (SMF1) (with 28 days fresh water curing) have energy absorption about 121.83 kN.mm, the specimen (SMF2) (with 56 days fresh water curing) improved the energy absorption about25.88 % over reference specimen (SMF1). In specimen (SMW1) (with 28 days fresh water curing) have energy absorption about 143.6 kN.mm, the specimen (SMW2) (with 56 days fresh water curing) improved the energy absorption about (22.63 %) over reference specimen (SMW1). Accordingly, the specimen (SMH2) (with 56 days fresh water curing) improved the energy absorption about 13.14 % over reference specimen (SMH1).

Table 10. Energy absorption of tested slabs

Specimens Symbols	Energy absorption (kN.mm)	Improvement (%)
SNF1	102.7	R*
SNF2	146.25	42.4
SNW1	114.83	R*
SNW2	132.84	15.68
SNH1	126.58	R*
SNH2	135.84	7.3
SMF1	121.83	R*
SMF2	153.36	25.88
SMW1	143.6	R*
SMW2	176.1	22.63
SMH1	147.7	R*
SMH2	167.11	13.14

4. Conclusions

The following conclusions can be gained from this study:

- The using of wastewater and hospital effluents water in curing of concrete reduced the ultimate carrying capacity of tested panels.
- The first crack load is affected negatively by using of wastewater in curing of concrete.
- There is a significant reduction in deflection of tested panels in case of using of wastewater in curing of concrete.
- The punching shear strength improved in pure water curing case.
- The mode of failure did not exchange by using of wastewater in curing of concrete.
- At 56 days of curing, the specimens cured with freshwater improved the punching shear strength higher than the specimens cured with wastewater and hospital effluents water.
- The specimens that were submerged 56 days in wastewater and hospital effluents water recorded an increase in first crack load lower than the increased achieved by curing the specimens in fresh water for 56 days curing time.
- The stiffness of fresh water cured specimens appeared higher than other specimens that cured with wastewater and hospital effluents water.
- Curing the specimens with fresh water for 56 days curing time improved the stiffness of tested slabs larger than the slabs that cured with wastewater and hospital effluents water.
- The energy absorption of fresh water cured specimens appeared achieved energy absorption higher than other slabs that cured with wastewater and hospital effluents water.
- Curing the specimens with fresh water for 56 days curing time increased the energy absorption of tested specimens larger than the slabs that cured with wastewater and hospital effluents water.

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6. Conflicts of Interest

The authors declare no conflict of interest.

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