Performance of Concrete Containing Rice Husk Ash in Lining of Open Channel

Saleh. I. Khassaf[1], Ali. T. Jasim[2], Fatimah.K. Mahdi[3].

Abstract— Control of water losses by lining canals is one of the important aspect to solve problem of Seepage from irrigation canals. In this research work was experimentally carried out to study the performance of concrete containing Rice Husk Ash (RHA) in lining canals, due to its great availability and low cost. In the presented research concrete specimens was molded with 10%, 20%, and 30% of (RHA) replacing the cement. Tests of water absorption, sorptivity and coefficient of water absorption indicate that it were decrease with the increase of RHA% until 20%. from the result of ponding test it can be concluding that it was a clearly reduction in the rate of seepage losses with the increase of RHA% replacement concrete until 20% where the reduction was recorded to be 34% and 67% for 10% and 20% RHA respectively, while when the %RHA increased to 30 the rate of seepage losses was more than it was in the control mix, where it was increased to 26% than that in the control mix for the older age thus, it can be concluded that used of rice husk ash (RHA) as partial replacement to 20% of ordinary Portland cement in concrete lining canals will reduce the rate of seepage losses from canals and improvement the properties of concrete which used in the lining canals.

Key words— Concret, Rice Husk Ash, Lining, Open channel.

1 Introduction

Water delivery to the land must be provided by a reliable and efficient irrigation system. A canal is frequently used to convey water for farmland irrigation. The conveyance canal and its related structures should perform their functions efficiently and competently with minimum maintenance, ease of operation, and minimum water loss.

Earthen irrigation channels in permeable soils can lose a lot of water through seepage. Large losses through the bed and sides of canal lead to low conveyance efficiency. It causes waterlogging in the area adjacent to channels while simultaneously reducing the amount of water available for safe and productive use(1). To reduce these losses, the bed and sides of the canal are provided with an impervious lining.Common materials of lining are Cement, Brick, Puddle clay, Stone blocks, Asphalt, Road oils, Tar and Bitumen(2). If cement, gravel and sand are relatively cheap and locally available, concrete lining is generally a good choice. Development of lining material that would be sufficiently low in cost as to permit economical lining of all canals and laterals will probably become possible. The use of supplementary cementing materials has gained considerable importance the last decade.There are many mineral admixtures that are used in way throughout the world like Silica fume (SF), fly ash (FA) and rice husk ash (RHA) are industrial and agricultural wastes, RHA concrete is like fly ash/slag concrete with regard to its strengthdevelopment but with a higher pozzolanic activity it helps the pozzolanic reactions occur at early ages rather than later as is the case with other replacement cementing materials(3). And rice husk ash stands out as an ecofriendly, sustainable and durable option for concrete. So this research was of great importance to study the possibility of adding rice husk ash to cement used in the concrete lining canals, Since this material is available, and improves the properties of concrete, especially in reducing the leakage phenomenon.

S. I. Khassaf1, A. T. Jasim2, F.K. Mahdi3
1. Professor, Civil Engineering Department, University of Bassra, Iraq.
2. Assistant Professor, Civil Engineering Department, University of Kufa, Iraq.
3. B.Sc. Civil Engineering Department, University of Kufa, Iraq

2 Experimental Work

2.1. Materials

2.1.1 Cement

Sulfate resisting Portland cement (Type V) was used in this study. The results indicate that the available cement conforms to the Iraqi specification (I-O-S) (No.5/1984)(4).

2.1.2Fine Aggregate (F.A)

Normal weight natural sand was used as fine aggregate in this. The results show that the physical and chemical properties of fine aggregate used in this work conform to the requirements of Iraqi specifications No .45/1984(5).

2.1.3Coarse Aggregate (C.A)

Crushed gravel of nominal maximum size 14mm was used in this work. The results show that the used coarse aggregate conform to the requirements of Iraqi specification No.45/1984(5).

2.1.4Rice Husk Ash (RHA)

The Rice Husks Ash (RHA) used in this investigation was obtained from Al- Abasia Farms in Kufa city. Burning of rice husks was carried out in a furnace with controlled in order to establish the optimum burning temperature and burning time. The combustion temperature was about 550◦C and duration time was 2 hours produced an ash with optimum properties(6). The result of chemical and

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physical analysis of the rice husk ash used in the study is given in table(1)

Table (1) Chemical analysis and surface area of used rice husk ash*.

Oxide composition	Oxide content %
SiO2	90.18
Al2O3	0.51
Fe2O3	0.17
CaO	2.64
MgO	0.70
SO3	1.25
Loss On Ignition	2.30
Surface area (blaine method) M2/Kg	97.75

* Physical analysis was conducted by Al-Kufa cement factory .

2.1.5 Mixing water

Potable water was used throughout this investigation for both mixing and curing of concrete.

2.2Pozzolanic Activity Index of Rice Husk Ash (RHA)

For the assessment of pozzolanic activity with cement , the method described in the ASTM C311-2004(7) was used. The pozzolanic activity of rice husk ash was found to be 110 % which conform to the requirement of ASTM C618- 2004 (min. 75 percent)(8).

2.3 Concrete Mixes

In this investigation concrete mixes with 10%, 20% and 30% of cement replacement by rice husk ash (RHA) in addition to normal lining concrete mix (MR) were used.

The normal concrete mix (MR) was designed to give a 28-day characteristic compressive strength of 28 MPa and workability of (70 ± 5 mm), the design of reference mix was performed in according with ACI 211.1 2005(9). The details of the mixes used throughout this investigation are given in table (2).

Table (2) details of the mixes used throughout this study.

Mix symbo	Cemen (Kg/m)	F.A (Kg/m	C.A (Kg/m)	RHA (Kg/m)	Water (Kg/m))	Slump (mm)
MR	350	660	1185	0	205	70
M10	315	660	1185	35	205	55
M20	280	660	1185	70	205	45
M30	245	660	1185	105	205	15

2.4 Mixing,Casting and curing of Concrete Specimens

Mixing process carried out by using a rotary type mixer for all mixes. steelmoulds were used in all the tests throughout this investigation. Before casting each specimen, the moulds were carefully oiled to be ready for casting fresh concrete. Concrete was placed by means of scoop in layers of approximately 50 mm depth. Each layer was compacted by means of rodding. The specimens were demolded after 24 hours from casting, marked and then completely immersed in tap water until the time of testing.

2.5 Measurement of Seepage

Various methods are in use for the estimation of seepage from the proposed canals as well as it's measurement in the existing once. Seepage from existing canals is usually evaluated by direct measurements by various methods are used as inflow-outflow method, ponding method, and seepage meter method. These methods have their merits, demerits and limitations which are well understood.

Ponding test method is considered the most accurate and dependable method for measuring canal seepage((10). Temporary watertight dikes or bulkheads are used to isolate reaches of a canal, water is impounded between the two dikes, and the time rate of drop in the water surface is measured. The rate of drop and the physical dimensions of the ponded reach provide the data necessary to compute the seepage loss To obtain satisfactory results, the ponded reach must be selected so as to avoid inflow or outflow which cannot be accurately measured. A modificatibn of the ponding method consists of adding water to the pond to maintain a constant water surface elevation. The accurately measured volume of water added is considered to be equal to the seepage loss, and the elapsed time establishes the rate of loss. Measurement of evaporation may be necessary when ponding a lined reach in which losses are low and evaporation may be rapid, particularly if a comparison of seepage rates before and after lining is to be made. Ponding tests are normally suspended during periods of precipitation (11).

Seepage rate for the ponding can be computed using the following formula by (12).

$$S = \frac{L(d1-d2)W}{L \times p \times T} \times 24 \qquad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where:

S = the average seepage in m3/ m2 / day.

W = the average top width of the canal cross-section, (m).

d1 = the initial water depth, (m).

d2 = the final water depth,(m).

p = the average wetted perimeter of the canal section ,m |(average of the initial and final perimeter = (pi + pf) / 2)(m).

L = the length of the canal reach , test section (m).

T = the duration of ponding ,h.

2.6Total water absorption test

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(100 mm) concrete cubes were used to determined the total absorption capacity according to B.S 1881 :part 122:1983(13).

2.7 Sorptivity Test

Sorptivity testing was performed in accordance with ASTM C 1585-04(14). The purpose was to determine the rate of absorption of water by unsaturated concrete .

2.8 Coefficient of water absorption test

Coefficient of water absorption is considered as a measure of permeability of water . This is measured by the rate of up take of water by dry concrete in a period of 1 h. The concrete specimens were preconditioned by drying in an oven at 105 ◦C for seven days until constant weight was reached .

Then allowed to cool in a sealed container for three days. The sides of the concrete samples were coated with transparent epoxy resin in order to allow the flow in one direction. Then the samples in a vertical position were kept partially immersed to a depth of 5 mm at one end while the rest of the portions were kept exposed to the laboratory air. The quantity of water absorbed during the first 60 min was calculated. Coefficient of water absorption values of RHA blended concrete specimens after 28 and 90 days of moisture curing were determined using the formula(15),

$$Ka = \left[\frac{Q}{a,}\right]^2 \times \frac{1}{3600} \quad \text{……………..(2)}$$

where:

Ka= The coefficient of water absorption (m2/s).

Q = The quantity of water absorbed (m3) by the oven dry specimen in time (t).

a,= The surface area (m2) of concrete specimen through which water penetrates.

2.9Ponding test

canal of Trapezoidal cross-section (with 0.65 m thickness of lining (16) and 1.5 m length) was constructed for all mixes of concrete lining as shown in plate (1).

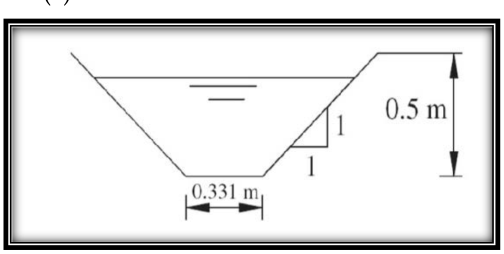

Plate (1) cross section of lining canal section.

The lining canal sections were closed by concrete plates in both ends with transparent epoxy resin in order to allow the seepage flow in the others sides direction only(17). the four channels were Placed outside the soil to separate the effect of saturation soil that surround the channels from the rate of seepage water losses as shown in plates (2) and (3).

Plate (2) lining canal sections.

Plate (3) tacking reading of water level

The canal filled with water to a certain measured level in the age of 7 days. After allowing the water to stand for some time, the level of water in the canal is recorded. then any drop in the level is obviously due to seepage through the section of canal was recorded. This volume of water, which is measured accurately, is equal to the total seepage loss during the particular time interval. The canal is then added sufficient quantity of water to maintain its original level and start again. The lining canal sections were placed inside laboratory and after all reading of water level in lining canal sections it were covered , to avoid effect of evaporation on the seepage losses rate. Ponding tests were conducted in each canal section in ages from (7-154) days. The duration of test continued around five months in order to show the development of permeability of the concrete lining canals with progress of concrete,s age. Readings were taken every week over a period of test, this gives a series of independent tests of the seepage rates in the same canal over a few days. When done in this way a ponding test has a considerable number of replications, which reduce the uncertainty in the mean result.

3 Results and Desiccations

3.1Water Absorption

The average test results for the water absorption shown in table (3)and Figs.(1). The percentage of water absorption decreases with

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increasing the age of moist curing from 7 to 90 days for all mixes during the hardening process of the concrete, where The lower water absorption was obtained at 90 days for all concretes.

Table (3). Results of total water absorption for concrete mixes.

Mix Designation	Total Water Absorption (%)			
	7 Days	28 Days	56 Days	90 Days
MR	2.83	2.22	1.9	1.42
M10%	3.02	2.25	1.75	1.16
M20%	3.37	2.39	1.56	1.02
M30%	3.61	2.53	2.04	1.73

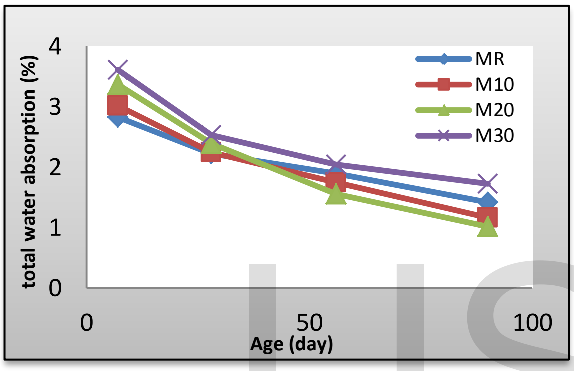

Fig.(1) water absorption value versus time with/without RHA

From the Table (4)and Fig.(2) it can be seen that at 28 days curing, the percentage of water absorption increases with RHA content up to 30% compared to the reference mix . This may be due to the nature of RHA particles which is hygroscopic. The increase in water absorption which is related to the increase in the amount of RHA can be resulted from the reduced amount of OPC(18). On the other hand, by increasing the age of curing to 56 and then 90 days, the percentage of water absorption values decreases significantly with the increase in RHA content up to 20%. The values were lower compared to reference mix. Therefore, it can be suggested that with prolonged curing, increasing the ages and percentages of RHA can lead to reduction in permeable voids. This is due to that the Pozzolan-lime reactions are slow.

3.2 Sorptivity

The sorptivity values calculated for RHA blended concrete specimens after 7, 28, 56 and 90 days of curing are also presented in table (4)and graphically in Fig.(2). It can be seen that the sorptivity progressively decreases with increase in RHA content up to 20%. This study have identified that commonly permeability of blended cement concrete is less than plain cement paste.

At 30%RHA there is an increase in sorptivity and these values are more than that of control concrete. This again confirms that prolonged curing leads to a reduction in pore space. It is also observed from the sorptivity data that 20% RHA replacement concrete specimens have shown a 28.1% reduction in sorptivity at 28 days compared to that of control(19).

Table (4) Sorptivity result for all mixes.

Mix Designation	Sorptivity × 10-6 (m/s1/2)			
	7 Days	28 Days	56 Days	90 Days
MR	4.55	4.062	3.912	3.80
M1%	3.87	3.25	2.982	2.83
M2%	3.67	2.90	2.732	2.55
M3%	4.64	4.39	4. 14	3.98

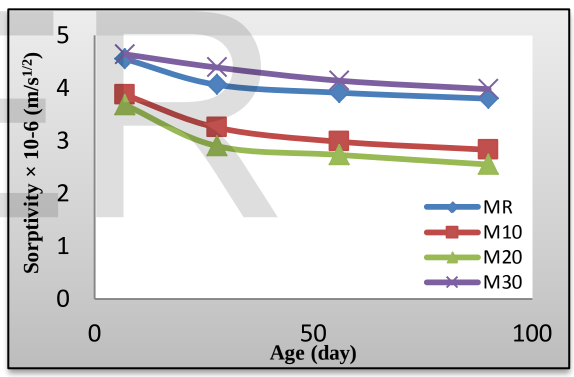

Fig.(2) Sorptivity test results versus age of curing.

3.3Coefficient of water absorption

The coefficients of water absorption of RHA blended concrete specimens are shown in Fig.(3). It can be seen that coefficient of water absorption progressively decrease with increase in RHA content up to 20%. For 30%RHA replacement concrete at the same age of 7, 28, 56 and 90 days, the values of coefficient of water absorption are higher than those of the reference concrete. Increases in coefficient of water absorption are attributable to the hygroscopic nature of the RHA and higher increases in these values were recorded at higher RHA replacements (15).

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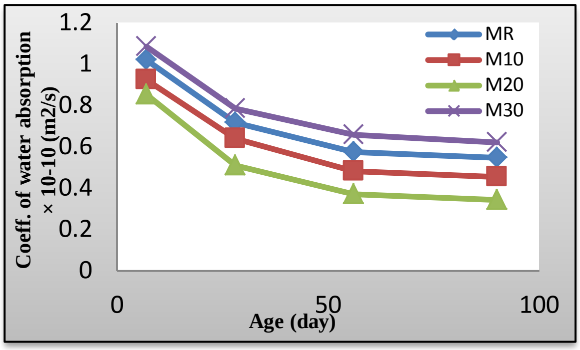

Fig. (3) Coefficient of water absorption versus time.

3.4 Ponding test results

Fig.(4) shows the relationship between seepage rate loss from the lining canals sections and time for all mixes from age of 7-day to 154-day i.e The time interval of the tests was 1–5months. For the four mixes of canal lining, the seepage rate was relatively large during the initial phase of the test, and gradually decreased with time until it approximately stabilized after the age of 90 days .

It clearly seen from the Fig.(3.4) that in the early ages the rate of seepage losses in the mixture of control mix (MR) which are lower than the others mixes which contains RHA. Then with theadvances inagethe decreasing in the rate of seepage losses in the 10-20%RHA being more than it in the reference mix.

After age of 90 days Fig.(3.4)showsthat the rate ofseepage losses for all mixes was approximately stabilized initially. As result of approximately completing of hydration process of concrete it was around 1.898, 1.251, 0.625 and 2.386 m3/m2/ day×10-3 for 0%, 10%, 20% and 30% RHA replacement concrete, from this result it can be concluding that it was a clearly reduction in the rate of seepage losses with the increase of % RHA replacement concrete until 20% RHA replacement where it was recorded to be 34.08% and 67.07% for 10% and 20% RHA, This confirms that the addition of the rice husk ash has possessive effect of reducing the rate of seepage losses of concrete lining, but this addition must be not increase, where it can be seen from the results showed in Fig. (3.4), that when the %RHA increased to 30 the rate of seepage losses was more than it was in the others mixtures, where it was increased to 25.71% than that in the control mix for the older age thus it can be say that the 30%RHA replacement concrete have an adverse effect on the rate of seepage losses of concrete lining.

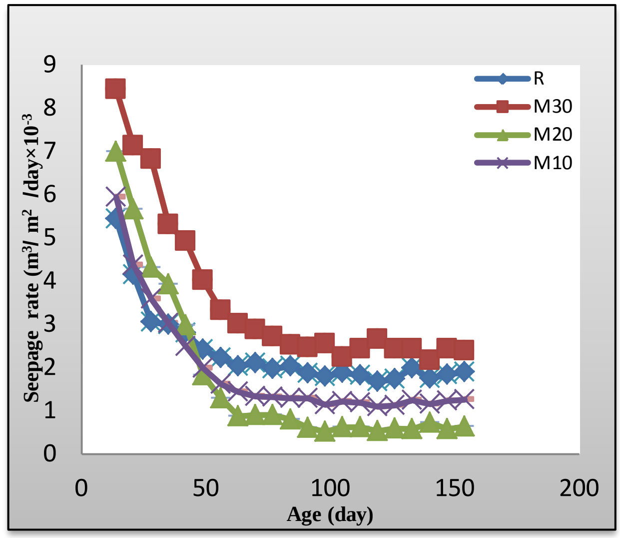

Fig. (4) the rate of seepage losses from the lining canals sections.

4 Conclusions

From the experiments and analysis of results of findings in this research work, the following facts are established about RHA replacement concrete lining canals.

1. The use of RHA considerably reduces the water absorption of concrete lining mix. A reducing of 39% was observed when compared to control sample. These results emphasize the beneficial effect of incorporating RHA to increase the durability of concrete.
2. Tests of sorptivity and coefficient of water absorption indicate that it was decrease with the increase of RHA% , from the sorptivity data it can be concluded that 20% RHA replacement concrete specimens have shown a 33% reduction compared to that of control at age of 90 days. Similarly There was an demerit of coefficient of water absorption to 37.5% for 20% RHA concrete replacement.
3. The results of the ponding test showed there it was a clearly reduction in the rate of seepage losses with the increase of % RHA replacement concrete until 20% RHA replacement where it was recorded to be 34% and 67% for 10% and 20% RHA respectively, while with increase of RHA replacement concrete to 30%, the rate of seepage losseswas increased to 26% than that in normal concrete.
4. It can be say that the RHA can be concluded that used of rice husk ash (RHA) as partial replacement to 20% of cement in concrete lining canals will bring several improvements for the concrete lining characteristics.

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