EFFECT OF RC AND SBR AS COATING CURING MATERIALS ON PROPERTIES OF HIGHWAY RIGID CONCRETE PAVEMENT

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Abstract

The surface to volume ratio of concrete pavement is large, also, due to hot climate of Iraq, coating concrete pavement after casting is essential to ensure vital curing, consequently to obtain significant engineering properties. This research work reports the results of a study performed to evaluate the engineering properties of concrete coated with concrete surface coatings solutions; two types of coating were used representing co-polymer (Styrene-Butadiene Rubber, SBR) and by-product material (Residue Crude, RC). Different coating solutions were prepared from these solutions, individually and collectively; i.e. 100% SBR, 75% SBR+25% RC, 50% SBR+50% RC, 25%SBR+ 75%RC, and 100%RC. The engineering properties of the uncoated and coated concrete samples were evaluated by assessing compressive strength, flexure strength and hardness for concrete convenience for highway rigid pavement. The compressive strength was evaluated for the specimens at 7, 14, 28 and 90 days, where flexure and hardness were evaluated at 28days.

The results showed that the coated samples with both SBR and RC performed noticeably better in contrast with uncoated samples under air-dry conditions. Additionally, obvious differences in the performance of the collective solutions were recognized. From the results, however, local by-product materials have been proven as a significant coating materials suitable to enhance the concrete used for pavement purposes.

Keywords: Compressive strength, Concrete pavement, Flexural strength, RC, SBR.

تاثير RC و SBR كمواد تغطية انضاج على خواص خرسانة بلطات الطرق الجاسئة

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الخلاصة

من الملاحظ ان نسبة السطح الى الحجم في الخرسانة المستخدمة للطرق عالية, كذلك بسبب الجو الحار في العراق, يكون تغطية الخرسانة بعد عملية الصب مهمة لضمان انضاج فعال, و بالتالي الحصول على خواص هندسية عالية. يقر هذا البحث نتائج دراسة تقيم خرسانة مغطاة سطحيا بمحاليل. وهذا المحاليل هي مادة الستارين بيوتدين ستارين SBR (مادة بولمراتية), ومادة ناتج عرضي من الصناعة النفطية هي رواسب الخام RC. عدة محاليل تغطية تم تحضيرها من هذين المحلولين بشكل مفرد او بخليط منهما: 100% SBR, 75% SBR+25% RC, 50% SBR+50% RC, 25%SBR+ 75%RC, 100%RC. تم تقيم الخواص الهندسية لنماذج الخرسانة المغطاة و غير المغطاة بمقاومة الانضغاط, مقاومة الكسر و الصلابة وبالطبع وفق متطلبات الخرسانة المستخدمة للبلاطات الجاسئة . وتم تقيم النماذج لمقاومة الانضغاط باعمار 7,14, 28, 90 يوم, بينما نماذج مقاومة الكسر و الصلابة باعمار 28 يوم.

وبينت النتائج زيادة ملحوظة في اداء الخرسانة المغطاة بال RC و SBR بالمقارنة مع الخرسانة المتروكة بدون تغطية تحت تأثير حرارة الجو. كما ان هناك فروقات ملحوظة ايضا في نتائج الاداء حسب نوع المحلول المستخدم. وكنتيجة ملموسة تم اثبات فعالية مادة ناتجة عرضيا من الصناعة المحلية في تحسين اداء الخرسانة المستخدمة في البلاطات الجاسئة كمادة تغطية للانضاج.

Abbreviations

ASTM	American Society for testing and Materials
AASHTO	American Association of State Highway and Transportation Officials
BS	British Institute
CDC	Coated before Dry Curing
DC	Dry Curing
RC	Residue Crude
SBR	Styrene-Butadiene Rubber
SRA	Shrinkage Reducing Admixture
WC	Wet Curing

1. Introduction

The surface to volume ratio of concrete pavement is large. However, in hot weather climate countries (such as Iraq), the need for providing supplementary protection to concrete pavement where the pavement panels are in early curing age is well appreciated, as the final engineering characteristics essentially related to. Excessive early-age evaporation will lead to insufficient water that required for completing the hydration process. Moreover, this could result in plastic shrinkage and cracking of the pavement surface, consequently low strength and durability, corrosion of steel, and loss of pavement service life (Ye et al., 2010, American Concrete Institute, 2001). Actually, one part water to 24 parts cement by weight is required during the earlier 7 days instead of the depleted mixed water due to hydration process(American Concrete Institute, 1997).

Two methods are used broadly as curing methods in highway pavement constructions; namely, supplying additional moisture by continuous application of water, or minimizing the water loss by either sealing or covering the concrete surface. However, excessive research works have been done to demonstrate the advantages and disadvantages of each curing method. Curing the pavement panels by continuous application of water (which is commonly used in local pavement construction) proved unsatisfactory, as the retention of water could be partially, furthermore, this curing method result in a low wear-resistance of the pavement surface(Scripture, 1942). On the other hand, burlap or insulating blankets respected as ideal curing method for retaining heat and moisture, but intensive labor and time is required(Wang et al., 2006).

Significant number of studies have been conducted on the effectiveness of sealing materials. For example, Wang et al. were found that the curing effectiveness is highly depends on the time of application and the generic type of the curing membrane (Wang et al., 1994). Other study conducted by Ibrahim et al. proved that the bitumen-based showed best performance as a curing compound in contrast to coal tar epoxy, acrylic-based or water-based materials(Ibrahim et al., 2013). In addition, they stated that initial period of water curing before curing compound is applied, could be beneficial in improvement of concrete durability. Whiting and Snyder investigated the effectiveness of high volatile organic compounds, low volatile organic compounds, plastic sheet and convectional lab water curing, on concrete strength and permeability(Whiting and Snyder, 2003). The results of mentioned study demonstrated, firstly, that all curing method is significantly better than no curing method in improving the strength and reduce the permeability of concrete. Secondly, great difference between different curing compounds is also found, in other words, it is not just sealing. The results of other attempt by Dang at el. Indicated that a double-coating by Shrinkage Reducing Admixture (SRA) can clearly minimize the drying shrinkage and moisture loss of concrete(Dang et al., 2013). Furthermore, water absorption rate and chloride penetration of the tested concrete are reduced noticeably. The same results were proved by other research studies as well (Saliba et al., 2011, Folliard and Berke, 1997, Bentz, 2006).

2. Research Aim and Scope

The present research work is aimed to investigate the effectiveness of a two curing compound materials on mechanical properties of concrete use for highway pavement. The first compound is a by-product material, which was selected as environmental friendly and cost effectiveness alternative for the available curing compounds, i.e. Residue Crude (RC). While, another acrylic-based compound widely utilized in concrete construction was selected for the following reasons:

- to minimize the RC dark color; it is believed that there is an essential relation between darkness of exposed surface and the sunlight absorption by the concrete surface, consequently, the rate of evaporation and the fresh concrete temperature.
- To minimize the RC viscosity; as shown in **Figure** 1 that incorporating SBR within RC, reduce the viscosity significantly, and consequently facilitate the application of such coating material in normal ambient temperature.

3. Research methodology

3.1 Materials and specimens preparation

The concrete mix used for the experimental program was compatible to the concrete specified by the Iraqi requirements for concrete of highway pavement(State Orgnization of Roads and Bridges, 2003). **Table** (1) shows the mix constituents that used to prepare the cubs and prism specimens. At least, three concrete cubes, or three prisms were prepared for each property variation. All the specimens constituents were satisfied the said requirements regarding gradation, SO3 content, soundness, material passing 200, etc.

Styrene-butadiene rubber (SBR) was utilized in the form of emulsion. **Table** (2) shows the physical properties of the SBR. Where **Table** (3) shows the properties of RC which was received from Al-Dura refinery plant as a by-product from distillation of crude oil.

3.2 Curing protocols

Three curing protocols were adopted in this study, consequently, three groups of specimens prepared to test after the specified curing periods, i.e. 3,7 ,28, and 90 days. All the specimens in the three groups left, initially, in the mold for 24 hours before de-molding and subjected to the classified curing protocol. However, first group specimens (wet curing, WC) immersed in water curing tank, while, second group specimens (dry curing, DC) left outside the lab directly under ambient weather conditions. The third group specimens (coated before dry curing, CDC), where the specimens coated with curing solutions before subjected to cure outside the lab under the ambient weather condition.

Five coating solutions were prepared from RC and SBR, individually and collectively; i.e. 100% SBR, 75% SBR+25% RC, 50% SBR+50% RC, 25%SBR+ 75%RC, and 100%RC. These curing solutions applied, firstly, to the upper face of specimen after 30 min of concrete casting, as can be seen in **Figure** (2), and then the other faces were coated after the de-molding 24 hours period to concrete casting. **Table** (4) illustrates the details of curing protocols and coating solutions.

3.3 Test methods

Concrete characteristics are frequently determined in mechanical and durability terms. Compressive strength and modulus of elasticity, and less repeatedly, tensile strength, shrinkage and creep are used as mechanical properties. Where, carbonation and chloride penetration resistance, and less repeatedly, water absorption and air/oxygen permeability are used to define durability. On the other hand, abrasion resistance is very rarely studied, comparatively; as the property is important in a special concrete part such as dams, spillways, pavement and floor where erosion action is expected (de Brito, 2009). In this research work, the influence of covering solution on the properties of hard concrete was determined by the following procedures:

i. **Moisture loss:** cylindrical specimens 50 mm diameter x 20 mm height were prepared to determine the moisture loss, according to ASTM C156 (ASTM, 2005), after 3, 6, 24, 48, 96, 192 and 336 hours of curing and/or application of covering solutions.
ii. **Compressive strength:** cubic specimens 100x100x100 mm were prepared to determine the compressive strength, according to BS 1881-116 (British Standards Institution, 1983), after 3, 7, 28, and 90 days of accomplishment of curing and/or application of covering solutions.
iii. **Flexural strength:** prism specimens 40x40x200 mm were prepared to determine the flexural strength, according to AASHTO T-97 (AASHTO, 2003), after 28 days of accomplishment of curing and/or application of covering solutions.
iv. **Hardness of surface:** cubic specimens 150x150x150 mm were prepared to determine the hardness of the concrete surface using rebound hammer, according to ASTM C 805 (ASTM, 2002), after 28 days of accomplishment of curing and/or application of covering solutions.

4. Results and Discussion

Moisture loss

Figure 3 demonstrates the moisture loss of cement mortar specimens coated with different coating solutions. Results obviously showed that the most moisture lost occur in the early curing time for all coated specimen types. However, it could be due to a combination of initial hydration process, bleeding and evaporation. Furthermore, uncoated specimens (DC specimens) exposed relatively higher loss of water. It is believed that unsealed surfaces demonstrates increment in the probabilities of evaporation from the surface, then, the dried upper portion minimizes the capillaries water from lower portion of the specimen by suction. In contrast, coated specimens (CDC specimens) disclosed significant saving of capillaries water, but with noticeable variation depends on the type of coating solution. However, it is suggested that the ability of the RC to prevent evaporation is more substantial than SBR. It is may be due to natural of the material itself, but also it could be due to the final ability of the material to supply sound thin cover. Results of optical microscopy picture suggested that the SBR thin layer showed some fragments, in contrast to

RC, which showed a complete homogenous tight layer, as can be seen in **Figure** 4. Thus, the hair space between these fragments could be represent evaporation zones.

Of course the results of loss of moisture reflect the variation in abilities of different solution to save retention water required to continue the hydration process and produce more hydration products, consequently, enhance the mechanical properties of the produced concrete which will be proven hereafter. Furthermore, minimizing the loss of moisture reduces the plastic shrinkage and tensile stress which could occur in the surface of the concrete and specially in pavement panels due to volume to surface are ratio (Neville and Brooks, 2010).

4.1 Compressive strength

As expected the development in compressive strength of specimens under continuing wet curing showed significant value in contrast to air dry curing without coating, this has been confirmed for all curing ages, as can be seen in **Figure** 5. In other words, the ratio of compressive strength over curing age of WC/ DC ranged from 118- 164 %, **Figure** 6, which alarms a noticeable reduction in strength in hot and dry weather climate, due to loss of water that necessary for continuation of hydration process. This range reflects the importance of the mention water; the low ratio noted in early ages, then steadily increased between 7 and 28 days, as the free water in the capillaries bleeds and evaporates, after that, slight difference between 28 and 90 days strengths' values.
On the other hand, coating concrete with the mentioned curing solutions offered valuable increase in compressive strength in contrast with uncoated specimens; again, this is confirmed for all curing ages. For all coating solution types, the ratio of strength over curing ages of CDC/DW showed the same trend regarding the development of strength. Although RC generally offer a better preservation to hold water in contrast to SBR, but CDC2 specimens' strength disclosed the higher values, **Figure** 6. However, this proves that the mixture of RC and SBR with high RC value is significant in preserve water in the capillaries of specimens subjected directly under sunlight, which approves the validity of lowering the darkness of the coating solution. it may said that the evaporation of water under direct sunlight is higher either with coating with RC, as the strength result not follow the loss of water test, whereas the loss of water conducted in lab environment.

4.2 Flexural strength

Results of the flexural strength of coated and uncoated concrete prisms at the age of 28 days (average of three results), are illustrated in **Figure** 7. The prisms had been subjected to the same curing protocols that mentioned in **Table** 4. Mostly, the flexural strength disclosed the same trend as the compressive strength testing behavior. Whereas, wet curing specimen showed the highest flexural strength, where the dry curing specimens showed the lowest; the flexural strength ratio of WC/DC was approximately 160%, as can be seen in **Figure** 8, normally because of the loss of water that required for hydration process. **Figure**s 7 and 8 obviously exposed that the high percentage of RC solution added better enhancement to flexural strength of dry curing specimens in contrast to SBR. The improvement in flexural strength ratio (CDC/DC) ranged from 9% with SBR coating solution, and was increased with increase of the percentage of RC up to 75%, where the improvement reached to about 30%. Then a reduction associated with specimens entirely coated with RC. The same explanation adopted to compressive strength improvement that mentioned previously might be adopted here as well, whereas the variation in ability of different type of coating solution in preserve the required water could be after the continuity of the hydration process, consequently development in flexural strength.

4.3 Hardness of surface

Resistance to wear or hardness is a vital characteristic for the concrete used for road purposes. Obviously, course aggregates hardness resists most of the abrasion resistance of tires repetitions, but the mortar hardness, simultaneously, represents the complementary skeleton of wear resistance. Although within the last 50 years, a numerous researcher tried to find a good relationship between compressive strength and rebound surface hardness, there is a significant diversity still found by proposed models (Szilágyi et al., 2011). However, abrasion has to measure by a tool other than compressive strength to represent the characteristics of concrete surface. The test method of rebound number described in ASTM C805 (ASTM, 2002) could bring an effective tool to measure the hardness of the concrete that facing vehicle tires, in other words abrasion resistance (Dhir et al., 1991). Taking in to account the fact that the evaporation and bleeding occurs in the top surface of the concrete panels, normally top lay of concrete panels represents the critical part, which should check.

Rebound number was determined on three 150x150x150 mm cube concrete samples according to ASTM C805 principles(ASTM, 2002), for each coating solutions and dry and wet curing protocol specimens. The results of the rebound number test on concretes are graphically shown in **Figure** 9. It was found that while the maximum rebound number was in WC specimens, the smallest was in DC specimens, which is normal, as the evaporation and bleeding occur at the surface of concrete. This process left the upper layer more permeable and has the lowest retention water that required for hydration process, consequently weaker concrete that reflects less rebound numbers. With respect to DC rebound numbers, CDC1, CDC2, CDC3,CDC4,and CDC5 showed 16%,20%,16%, 12% and 8%, enhancements, respectively, as a result of coating process, as can be seen in **Figure** 10 . The reason for these enhancements could be explained by the verity of different coating solutions to preserve water. However, using these solutions present a development in abrasion resistance in term of rebound number.

5. Conclusions

From results of this research work, the following can be concluded and recommended:

1. Incorporating SBR into RC significantly reduces the produced solution viscosity, which bring a beneficial effect in terms of coating application process. However, the new produced solution can be spread easily over the concrete pavement panels, without heating process.
2. Application of coating solutions in hot weather climate, considerably reduce the loss of water and evaporation of the water needed to continue the hydration process in the early age of concrete.
3. Over all laboratory test results demonstrated significant improvements in mechanical properties of the concrete that coated in contrast with uncoated air dried concrete, i.e., the compressive strength, flexural strength and hardness increase with range between 8-64% depends on solution type, property type and age of concrete.
4. Base on laboratory test results, application of a solution with 25% SBR and 75% RC on concrete demonstrated the best practice for improving the mechanical properties of concrete pavement. These results could be due to the effectiveness of the RC to provide sound layer which prevent the water evaporation, at the same time, the incorporating of SBR help in reduce the darkness of the surface where the absorption of the sunlight less, consequently minimizing the surface layer temperature and the evaporation of the water.
5. Results proved that by-product bitumen base material such as RC could produce a respectable and dependable coating compound, either if it use without any treatment or modification, which bring outstanding beneficial impact on quality, environment and cost of produced concrete.

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References

[1] AASHTO 2003. Standard Method of test for: Flextural Strength of Concrete (Using Simple Beam with Third Point-Loading),AASHTO T-97. American Association of State Highway and Transportation Officials,Washington,D.C.

[2] AMERICAN CONCRETE INSTITUTE 1997. GUIDE FOR CONCRETE HIGHWAY BRIDGE DECK CONSTRUCTION. American Concrete Institute,USA.

[3] AMERICAN CONCRETE INSTITUTE 2001. Guide to Curing Concrete. American Concrete Institute,USA.

[4] ASTM 2002. Standard Test Method for Rebound Number of Hardened Concrete. C 805, American Aociety for Testing Material, West Conshohocken, PA 19428-2959, United States.

[5] ASTM 2005. Standard Test Method for Water Retention by Liquid Membrane-Forming Curing Compounds for Concrete. C 156, American Aociety for Testing Material, West Conshohocken, PA 19428-2959, United States.

[6] BENTZ, D. P. 2006. Influence of Shrinkage-Reducing Admixtures on Early-Age Properties of Cement Pastes. *Journal of Advanced Concrete Technology,* 4**,** 423-429.

[7] BRITISH STANDARDS INSTITUTION 1983. BS 1881-116: Testing concrete —Part 116: Method for determination of compressive strength of concrete cubes. London, UK.

[8] DANG, Y., QIAN, J., QU, Y., ZHANG, L., WANG, Z., QIAO, D. & JIA, X. 2013. Curing cement concrete by using shrinkage reducing admixture and curing compound. *Construction and Building Materials,* 48**,** 992-997.

[9] DE BRITO, J. 2009. Abrasion resistance of concrete made with recycled aggregates. *International Journal of Sustainable Engineering,* 3**,** 58-64.

[10] DHIR, R. K., HEWLETT, P. C. & CHAN, Y. N. 1991. Near-surface characteristics of concrete: abrasion resistance. *Materials and Structures,* 24**,** 122-128.

[11] FOLLIARD, K. J. & BERKE, N. S. 1997. Properties of high-performance concrete containing shrinkage-reducing admixture. *Cement and Concrete Research,* 27**,** 1357-1364.

[12] IBRAHIM, M., SHAMEEM, M., AL-MEHTHEL, M. & MASLEHUDDIN, M. 2013. Effect of curing methods on strength and durability of concrete under hot weather conditions. *Cement and Concrete Composites,* 41**,** 60-69.

[13] NEVILLE, A. M. & BROOKS, J. J. 2010. *Concrete Technology,* London, UK, Pearson Education Limited

[14] SALIBA, J., ROZIÈRE, E., GRONDIN, F. & LOUKILI, A. 2011. Influence of shrinkage-reducing admixtures on plastic and long-term shrinkage. *Cement and Concrete Composites,* 33**,** 209-217.

[15] SCRIPTURE, E. W. 1942. *Method of curing concrete*.

[16] STATE ORGNIZATION OF ROADS AND BRIDGES 2003. GENERAL SPECIFICATION FOR ROADS AND BRIDGES. Ministry of Housing and Construction, Iraq.

[17] SZILÁGYI, K., BOROSNYÓI, A. & ZSIGOVICS, I. 2011. Rebound surface hardness of concrete: Introduction of an empirical constitutive model. *Construction and Building Materials,* 25**,** 2480-2487.

[18] WANG, J., DHIR, R. K. & LEVITT, M. 1994. Membrane curing of concrete: Moisture loss. *Cement and Concrete Research,* 24**,** 1463-1474.

[19] WANG, K., CABLE, J. & GE, Z. 2006. Evaluation of Pavement Curing Effectiveness and Curing Effects on Concrete Properties. *Journal of Materials in Civil Engineering,* 18**,** 377-389.

[20] WHITING, N. & SNYDER, M. 2003. Effectiveness of Portland Cement Concrete Curing Compounds. *Transportation Research Record: Journal of the Transportation Research Board,* 1834**,** 59-68.

[21] YE, D., SHON, C., MUKHOPADHYAY, A. & ZOLLINGER, D. 2010. New Performance-Based Approach to Ensure Quality Curing during Construction. *Journal of Materials in Civil Engineering,* 22**,** 687-695.

Table (1): concrete mix constituents used to prepare concrete specimens

Constituent	Cement content	Coarse Agg.	Fine Agg.	W/c
Unite	(kg/m^3)	(kg/m^3)	(kg/m^3)	%
Value	375	1079	610	0.5

Table (2): Physical Properties of Styrene-butadiene rubber (SBR)

	sp. gr. (20 oC)	Viscosity (20°C, cP)	pH (20°C)	Total solids (wt%)
SBR	0.954	171	9.1	40

Table (3): Physical Properties of Residue Crude

	sp. gr. (20°C)	Viscosity (20°C, cP)	Flash point (°C)	fire point (°C)
RC	1.001	2640	140	175

Table (4): details of curing protocols and coating solutions.

Protocol no.	Abbreviation	Before de-molding	After de-molding
1	WC	24 hrs. in lab air curing temp. 25± 2 ºC, RH= 50±5	Continuous immersing in water path at 20ºC ± 2 tile testing time
2	DC	24 hrs. in lab air curing temp.= 25± 2 ºC, RH= 50±5	Continuous air curing out side lab at temp.=34ºC ± 5 , RH=15±5,tile testing ti me
3	CDC1	Specimens left to dry for 30 min, then coated the free surfa ce with coating solution (100% Rc), after that left for 24 hr s. in lab air curing temp.= 25± 2 ºC, RH= 50±5	Coating the other specime n surfaces with coating so lutions, then continuous ai r curing outside lab at tem p.=34ºC ± 5 , RH=15±5,ti le testing time
	CDC2	Specimens left to dry for 30 min, then coated the free surfa ce with coating solution (75% RC+ 25% SBR), after that l eft for 24 hrs. in lab air curing temp.= 25± 2 ºC, RH= 50± 5	
	CDC3	Specimens left to dry for 30 min, then coated the free surfa ce with coating solution (50% RC+ 50% SBR), after that l eft for 24 hrs. in lab air curing temp.= 25± 2 ºC, RH= 50± 5	
	CDC4	Specimens left to dry for 30 min, then coated the free surfa ce with coating solution (25% RC+ 75% SBR), after that l eft for 24 hrs. in lab air curing temp.= 25± 2 ºC, RH= 50± 5	
	CDC5	Specimens left to dry for 30 min, then coated the free surfa ce with coating solution (100% SBR), after that left for 24 hrs. in lab air curing temp.= 25± 2 ºC, RH= 50±5	

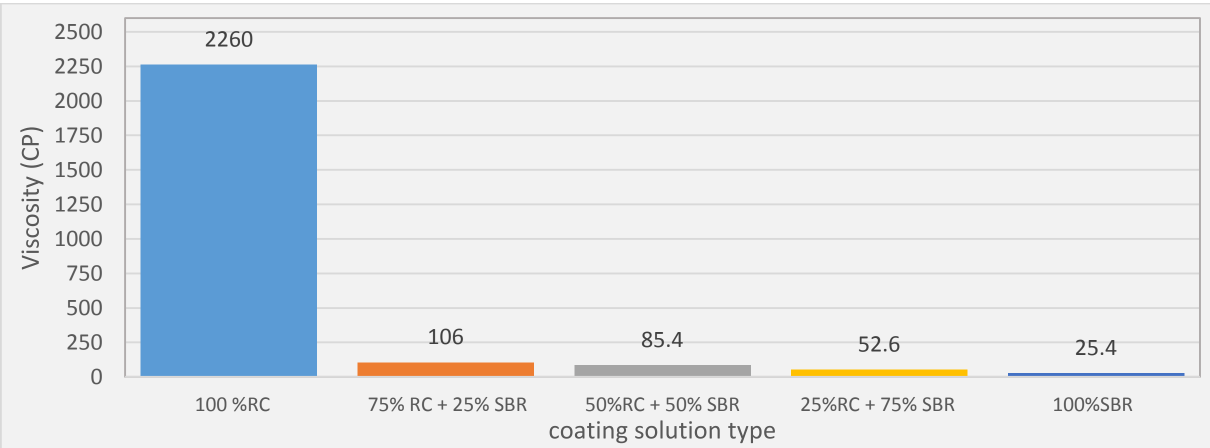


Figure (1): Coating solutions viscosity at 25 ºC

Figure (2): covering the specimens with curing solutions after 30min of casting

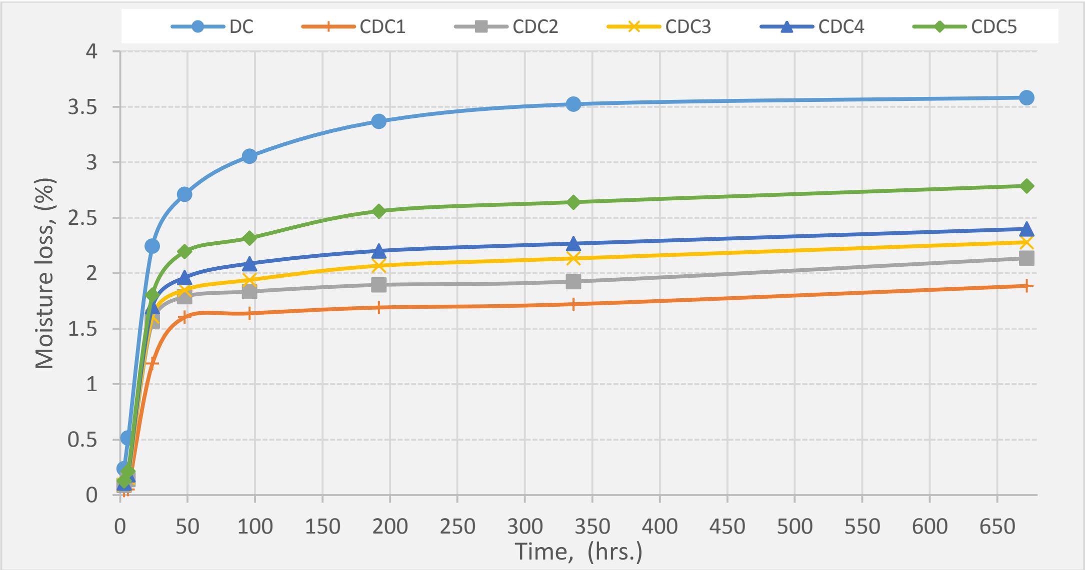
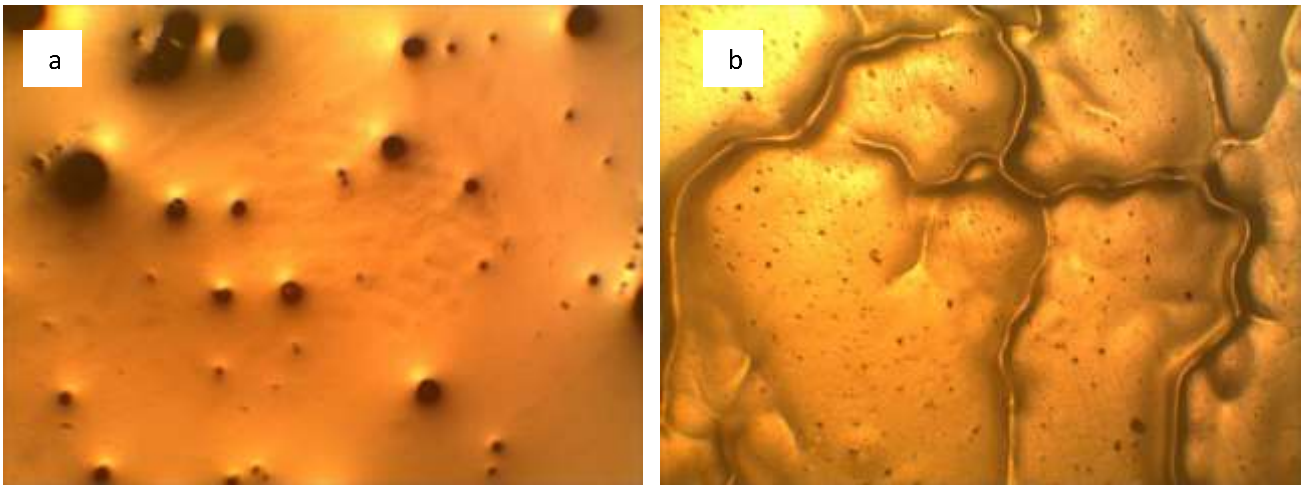


Figure (2): Effect of coating solution type on moisture loss of cement mortar



Figure(4): Optical Microscopy of a) RC, b) SBR

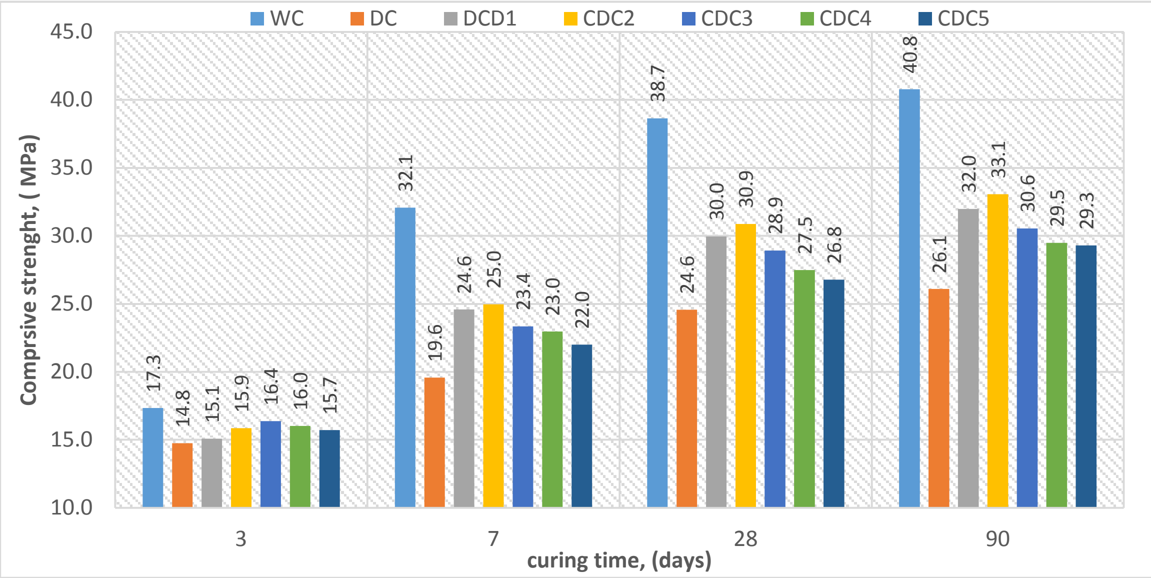


Figure (5): Effect of coating solution on compressive strength

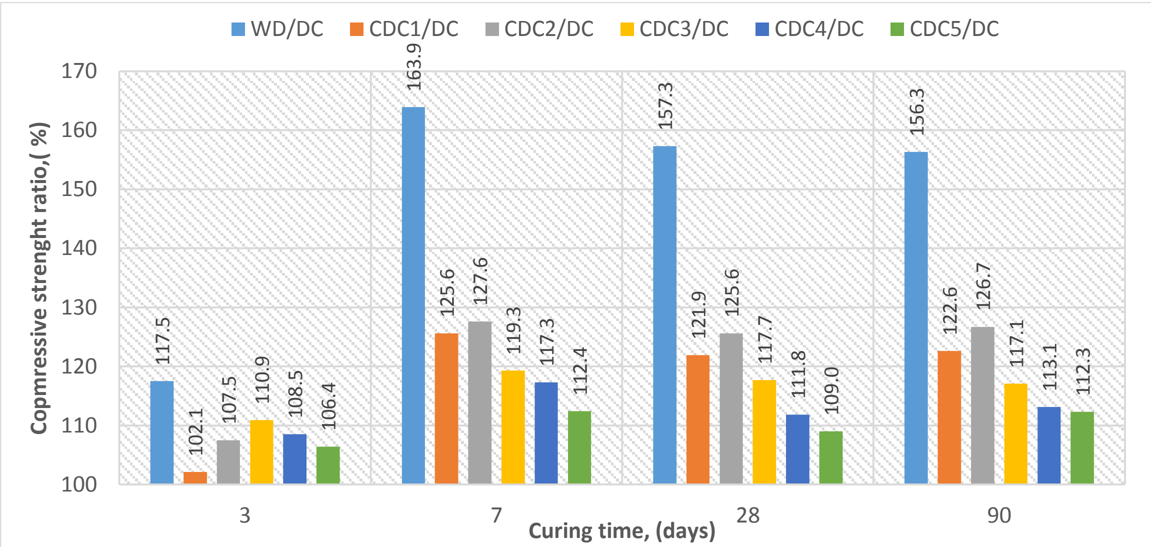


Figure (3): Effect of coating solution on compressive strength ratio

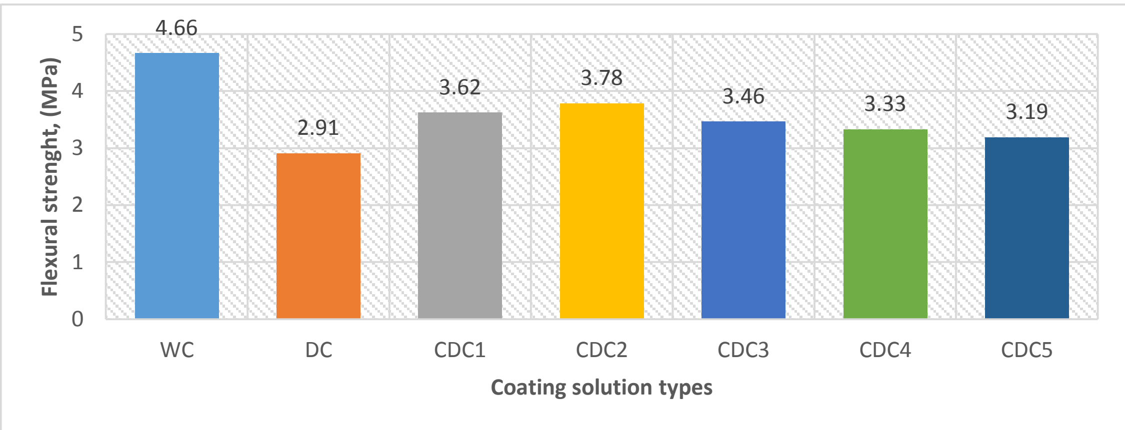


Figure (4): Effect of coating solution on flexural strength

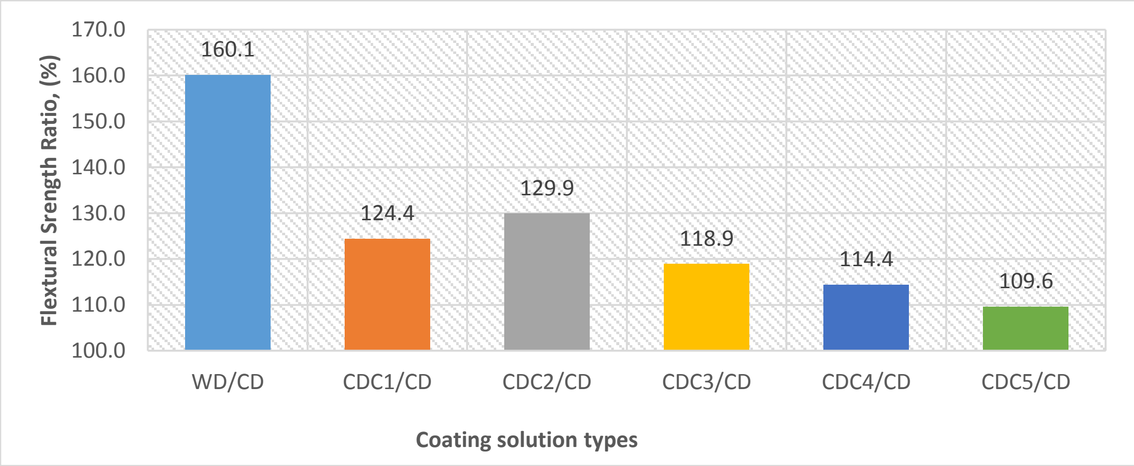


Figure (5): Effect of coating solution on Flexural strength ratio

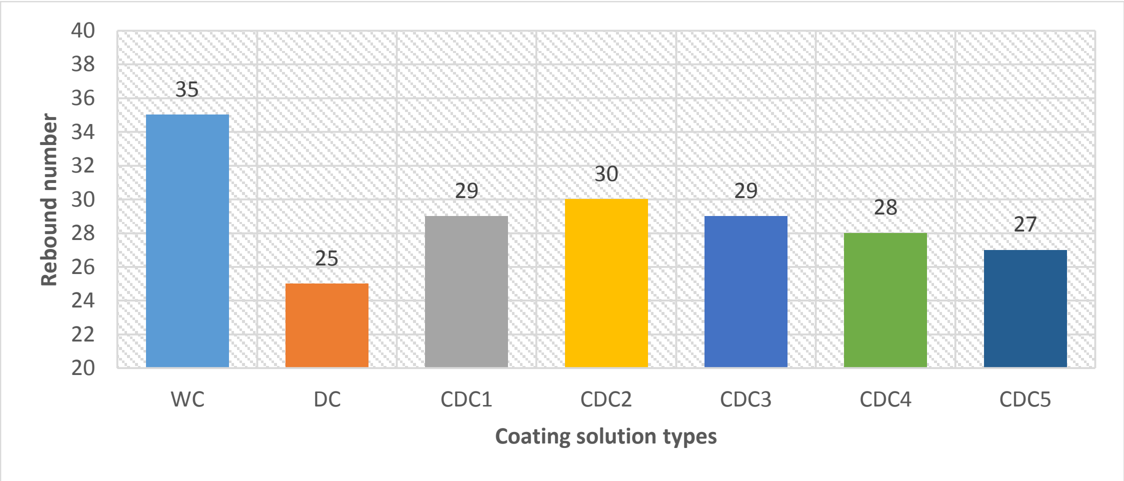


Figure (6): Effect of coating solution on rebound number

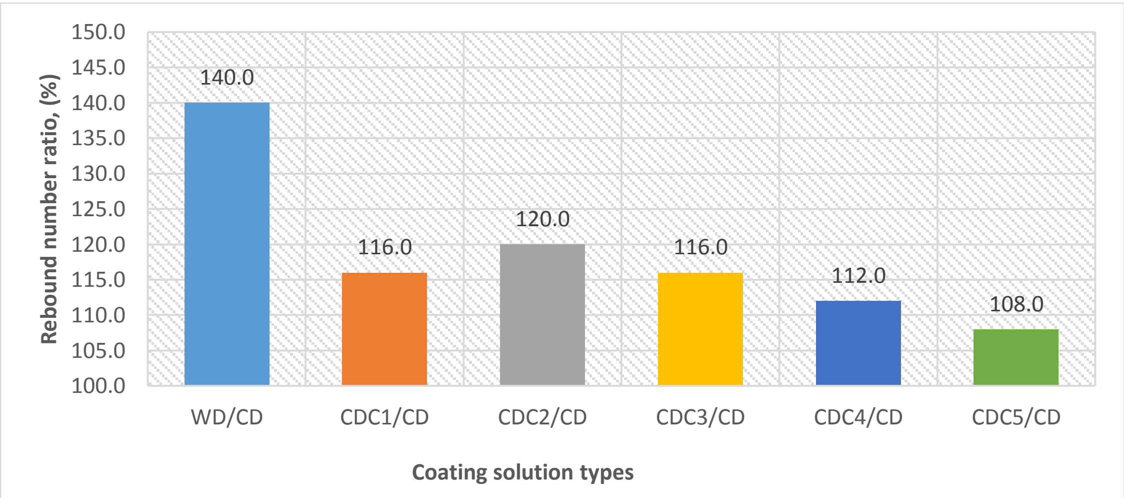


Figure (7): Effect of coating solution on rebound number ratio