

THE IMPACT OF THE TIME WHEN CASTING THE SECOND LAYER OF CONCRETE ON ITS MECHANICAL PROPERTIES

H. A. Mohamadien

*Civil Engineering Department, Faculty of Engineering, Suez Canal University, Ismailia, Egypt,
Email: h_mohamadien@yahoo.com*

Received 16 March 2013, accepted 30 April March 2013

ABSTRAT

Cold joint is one of concreting problem due to delay of casting the second layer. This is due to glitch of one of mechanical machines such as the concrete mixer, concrete truck, concrete batching plants, concrete pumps, and concrete mobile; that cause the stopping of the casting process which produce forced separator. Forced separation is different from known separators like: construction joint, expansion joint and settlement joint, where its location event and shape cannot be determined moreover the design engineer cannot put that in mind during the design phase of building construction. Therefore, the target in this work is to study the effect of delay in time period when casting the second layer of concrete after 4, 9, and 16 hour for two types of concrete with compressive strength 250 kg/cm² and 300 kg/cm². Eexperimental work was performed at laboratory to investigate the mechanical properties of concrete (compressive strength, splitting tensile strength and flexural strength), first when sprinkle the first layer with water before casting and second when coated with a grout material. The results were investigated and it indicates that, in case of delaying in the time period for casting the second layer, there is a great effect on the mechanical properties of concrete and the use of grout coating material in forced separation has a positive impact on improving its mechanical properties.

Keywords: delay in casting concrete, forced separation, concrete joints

1. Introduction

Processes of casting concrete in flat slabs, raft foundation and massive concrete may be faced delay in time period due to many reasons, such as glitch in casting machine that causes the stopping of the casting process for a period that can produce a forced layer separation. Therefore, knowledge of the setting characteristics of concrete is rather important in the field of concrete construction, these will help in scheduling the various stages involved in concrete construction operations such as transporting, placing, compacting and finishing of concrete. Setting of concrete is the gradual transition from liquid to solid, and the definition of any point at which the paste is considered set, is somewhat arbitrary, Nevi Alle and A.M. ^[1]. Final setting of concrete relates to the point where stresses and stiffness start to develop in freshly placed concrete. It has been reported that the initial thermal gradient at setting (built-in curling) has a major impact on the long-term performance of jointed concrete pavement, Yu et al ^[2]. Placing of concrete may be delayed from the time of mixing due to many reasons. The investigation carried out by R. Sri Ravindrarajah^[3], it showed that although the delay causes considerable loss in workability, there was no detrimental effect on compressive strength for concretes with or without set-retarding admixture or superplasticizer. Incremental addition of superplasticizer was capable of maintaining the concrete slump within a small variation

throughout the delay period. The effectiveness of superplasticizer to improve the workability was found to be a function of initial slump and the age of fresh concrete. Initial and final setting times can be estimated within practicable ranges provided that mixture-specific setting-maturity relationship and activation energy are used, S. A. Wade^[4].

2. Materials used in mixture

2.1. Concrete material

Concrete mix was prepared from available local materials, natural siliceous sand, crushed dolomite from Ataka quarries, ordinary Portland cement (OPC) and tap drinking water. These materials were tested according to the relevant Egyptian Standard Specifications. The physical and mechanical characteristics of the fine and coarse aggregates are shown in Tables (1 and 2) respectively. The test results indicate that both fine and coarse aggregates comply with the limits of Egyptian Standard Specifications No.1109-2003^[5]. Ordinary Portland cement was used in preparation all concrete mixes; Table (3) shows the physical and mechanical characteristics of the used cement.

Table 1
Physical properties of fine aggregate

Property	Results	Limits of ESS 1109 ^[5]
Specific Weight	2.50	2.5 - 2.75
Bulk Density (t/m ³)	1.73	-----
Clay and Fine Dust Content (% By Volume)	0.76	Not more Than 3

Table 2
Physical and mechanical properties of coarse aggregate

Property	Results	Limits of ESS 1109 ^[5]
Specific Weight	2.52	-----
Bulk Density (t/m ³)	1.51	-----
Water Absorption %	2.05	Not more than 2.5
Abrasion Index (loss Anglos apparatus) %	23.3	Not more than 30

2.2. Bonding materials (grout)

Grout consists of a cementations mix with grey colour and density 1.7 kg/ l mixed with water of ratio water/grout 2:1 to produce a used liquid mortar, it used for bonding between the old and new concrete.

Table 3
Physical properties of ordinary Portland cement

Property		Results	Specifications Limits ^[6]
Compressive Strength of Standard Mortar (Map)	3 days	21.4	Not less than 18 *
	28 days	39.7	Not less than 36 *
Specific surface area (cm ² /gm.)	-	3120	>2750 *
	Initial	135	Not less than 45 *
Setting Time (min)	Final	180	Not more than 600 *

* Egyptian Code of Practice for Concrete Structures No. 203-2007^[6]

3. Experimental program

3.1. Concrete mixes

The method of mix design in this work was the absolute volume method and the following equation was used,

$$\frac{C}{\gamma_c} + \frac{S}{\gamma_s} + \frac{G}{\gamma_g} + \frac{W}{1} = 1000 \text{ liters}$$

Where C, S, G, W, is Cement, Sand, Gravel and Water respectability in kg/m³ and γ is the specific weight. Two mixtures were used with compressive strength 250kg/cm² and 300kg/cm² and the slump test for both of them was 10±2cm. Table (5) shows composition of designed mixtures.

Table 5
Concrete mixture proportions at slump = 10±2cm

Materials	compressive strength	
	250 kg/cm ²	300 kg/cm ²
Cement (kg/m ³)	322	367
Water (kg/m ³)	200	200
Natural sand (kg/m ³)	447	412
Crushed stone (10 mm) (kg/m ³)	671	680
Crushed stone (20 mm) (kg/m ³)	549	556
Water/cement	0.62	0.55

3.2. Tests procedure

Tests were done according to Egyptian Standard Specification "Testing of Concrete" [7]. Factors taken in consideration during experimental work were as follow:

- a. Slump test conducted on fresh concrete to determine the slump value for the two types of the concrete.
- b. The casting directions of concrete were parallel to the direction of separator and the other was perpendicular to it. Figure (1) shows the casting directions.



Fig. (1)

- c. The separator in concrete molding, paint once with grout and the other sprinkle with water
- d. Two type of concretes 250 kg/cm^2 and 300 kg/cm^2 were used in the experimental program.
- e. The second layer of concrete was cast after 4, 9 and 16 hours for these two types of concrete with compressive forces 250 kg/cm^2 and 300 kg/cm^2
- f. all the cast specimens were covered by plastic sheets and left in the laboratory at $20 \pm 3^\circ\text{c}$ for 24 hour then transferred to a saturated water curing tank at 25°c until the age of testing.
- g. Three concrete cubes with side length 150mm for each type of concrete were casting taking into consideration direction and the time period of casting the second layers that were tested for compressive strength at 28 days after curing.
- h. Three cylinder molds with dimension $150_{\text{mm}} \times 300_{\text{mm}}$ were casting taking into consideration direction and time period of casting the second layers that were tested for determination of splitting tensile strength at 28 days after curing.
- i. Three beams of dimensions $100_{\text{mm}} \times 100_{\text{mm}} \times 500_{\text{mm}}$ were casting taking into consideration direction and time period of casting the second layers that were tested for the determination of flexural strength at 28days after curing as shown in Figure (2).



Fig. (2)

4. Results and discussion

4.1. Compressive strength

Figure (3) shows relation between relative compressive strength when casting the second layer of concrete of 250 kg/cm^2 and time when the concrete separator will be in the same direction of test loading. It was noted that the compressive strength was decreased with increasing the time period between casting of the first and second layer, and had no major effect on compressive strength at time 4 and 9 hours when coated the separation between the two layers by grout or water. The compressive strength of concrete was decreased by 15% when the second layer was casted after 16 hour in case of splashing the separator with water while decreased by 11% when coating the separator with grout, this may be due to the effect of final setting of cement. Figure (4) shows the relationship between the relative of compressive when casting the second layer of concrete 300 kg/cm^2 after 4, 9, 16 hours of time casting the first layer. It can be noticed that: there was a good influence on the properties of the compressive strength when painting the separator with material grout at time 4, 9 and 16 hours during casting the second layer of concrete and has no major effect when splashing the separator with water. The reduction in the compressive strength was (3% and 4% and 7%) at time 4, 9 and 16 hour when painting the separator with grout while it was (8% and 11% and 14%) when splashing the separator with water respectively, due to the enhancement of grout on bonding between the two layers.

Figure (5) shows Relationship between compressive strength of concrete $250, 300 \text{ kg/cm}^2$ and time when the separator is in same direction of load while painting the separator with and without grout. It was observed that the impact of grout on concrete target 300 kg/cm^2 has more effect than target 250 kg/cm^2 when the separator paint with grout.

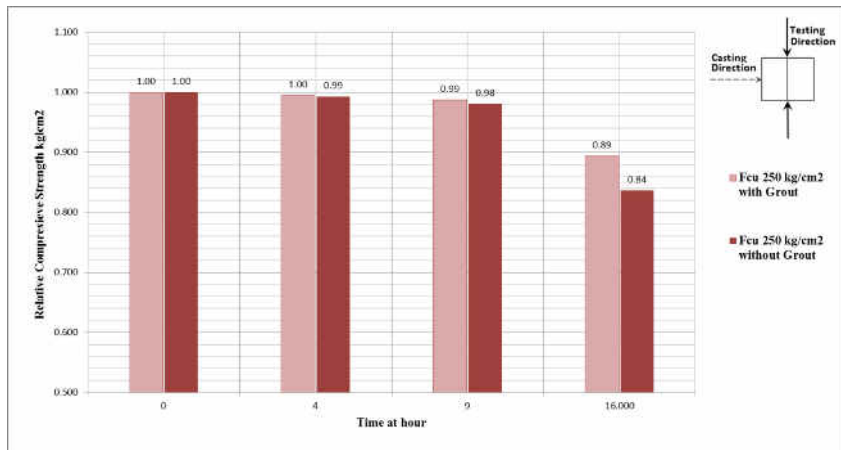


Fig. 3. Relative Compressive strength and delay in time when the separator is in same direction of load test of concrete 250 kg/cm²

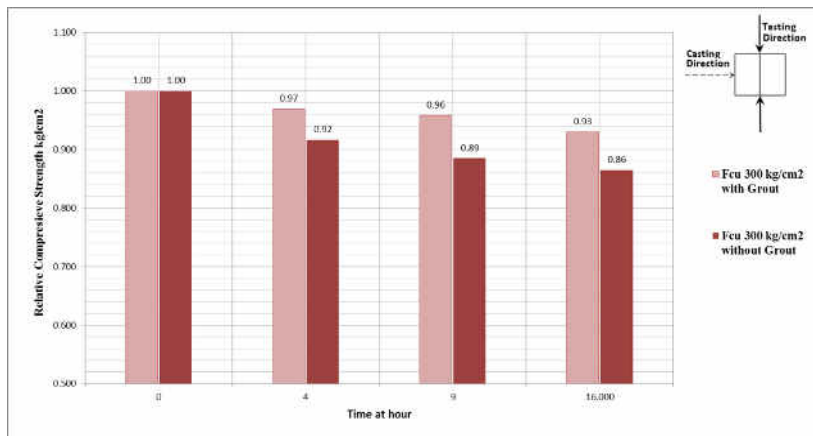


Fig. 4. Relative Compressive strength and delay of time when the separator is in same direction of load test of concrete 300 kg/cm²

4.2. Splitting tensile strength

Figure (6) present the relation of the splitting tensile strength and different times casting the second layer of concrete target 250kg/cm². It was observed that: The tensile strength of concrete mixtures at casting the second layer of concrete after (4 and 9 hours), has no major effect on splitting tensile strength. While at casting the second layer of concrete with grout after (16 hours), it has a slight decrease in the tensile strength of concrete. The tensile strength of concrete without grout is reduced by 11%, comparing with control mixtures at 28 days.

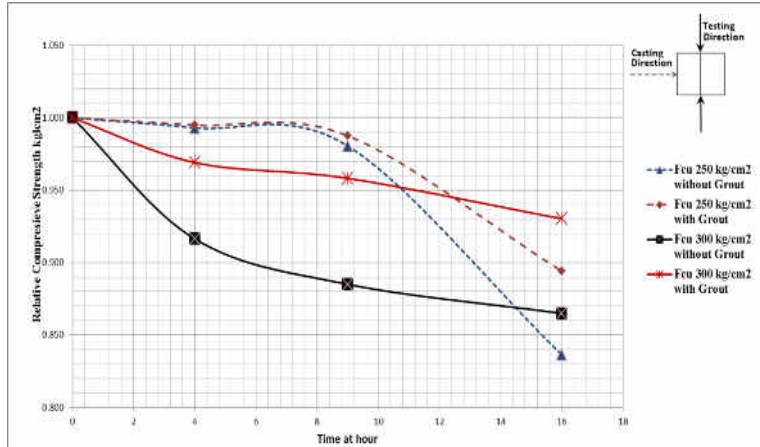


Fig. 5. Relative Compressive strength and delay in time when the separator is in same direction of load test of concrete 250, 300 kg/cm²

Figure (7) presents the relative of the splitting tensile strength and different times casting the second layer of concrete target 300kg/cm². It was observed that the tensile strength of concrete mixtures at casting the second layer of concrete with grout after 4 and 9 hours, has no major effect on tensile strength, After 16 hours, there is a slight decrease in the tensile strength of concrete by 7%. At casting the second layer of concrete without grout after 4 and 9 hours, there is a reduction in the compressive strength by 3% and 12% respectively. On the other hand, the tensile strength of concrete without grout after 16 hours is reduced in the tensile strength by 27%, comparing with control mixtures at 28 days.

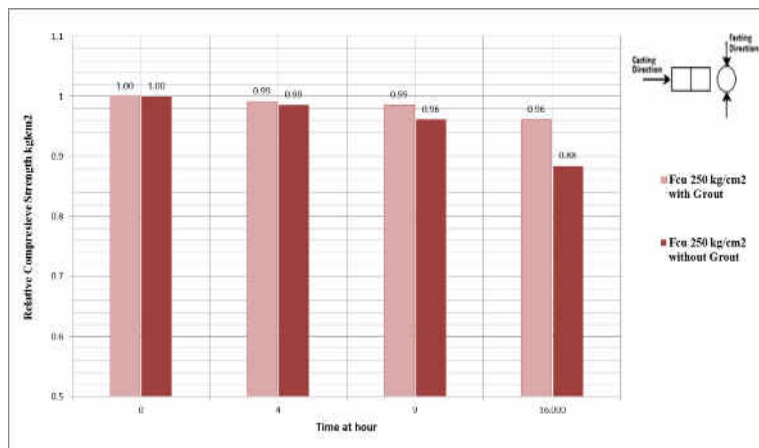


Fig. 6. Relative of splitting tensile strength and delay in time of concrete 250 kg/cm²

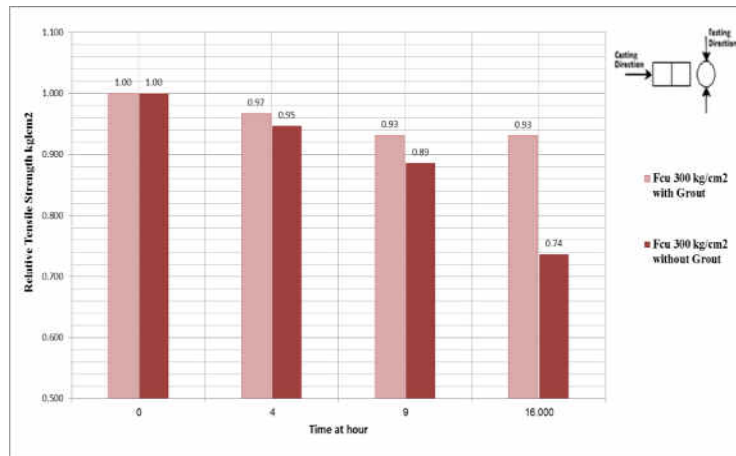


Fig. .7. Relative splitting tensile strength and delay in time of concrete 300 kg/cm²

Figure (8) shows Relationship between splitting tensile strength of concrete 250, 300 kg/cm² and time when the separator is in the same direction of load when painting the separator with and without grout. It can be seen that the impact of grouts on concrete target 300 kg/m² has more effect than target 250 kg/cm² when the separator paint with grout.

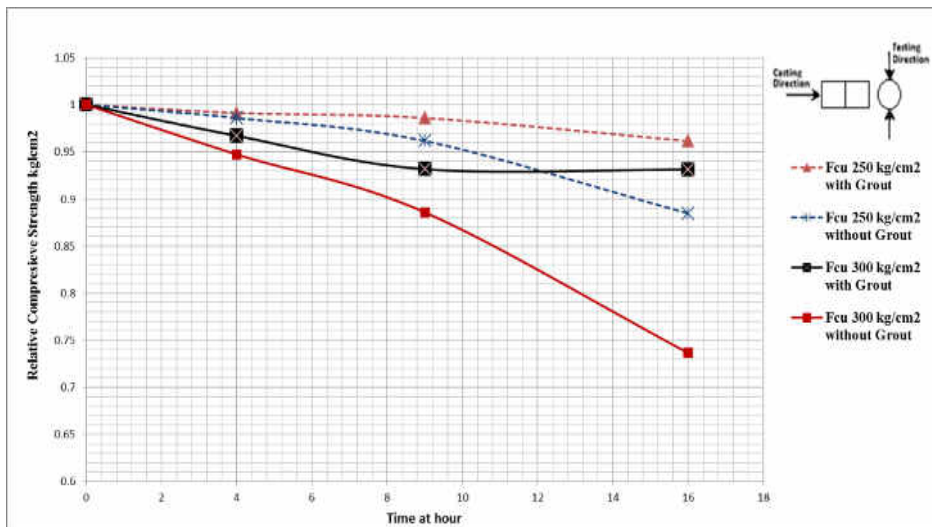


Fig. 8. Relative splitting tensile strength and delay in time of concrete 250, 300 kg/cm²

4.3 . Flexural strength

Figure (9) present the relation of the flexural strength and different times casting the second layer of concrete target 250kg/cm^2 . It was observed that: The flexural strength of concrete mixtures at casting the second layer of concrete with or without grout after (4 hours) is reduced in the flexural strength by 10%. On the other hand, at casting the second layer of concrete with grout after (9 and 16 hours) there is a decrease in the flexural strength of concrete by (22% and 35%) respectively. The flexural strength of concrete without grout is reduced by (25% and 40%) respectively, comparing with control mixtures at 28 days.

Figure (10) presents the relation of the flexural strength and different times casting the second layer of concrete target 300kg/cm^2 . It was observed that, the flexural strength of concrete mixtures at casting the second layer of concrete with grout after (4 hours), has no effect, while the flexural strength of concrete without grout, and is reduced in the flexural strength by 12%. At casting the second layer of concrete with grout after (9 and 16 hours) there is a decrease in the flexural strength of concrete by (9% and 30%) respectively, while the flexural strength of concrete without grout is reduced in the flexural strength by (20% and 43%) respectively, comparing with control mixtures at 28 days.

Figure (11) shows Relationship between flexural strength of concrete $250, 300 \text{ kg/cm}^2$ and time. In case of the separator is in perpendicular direction of test load while painting the separator with and without grout. It can be seen that the impact of grouts on concrete target 300 kg/m^2 was more effect than target 250 kg/cm^2 at time 4 and 9 hour.

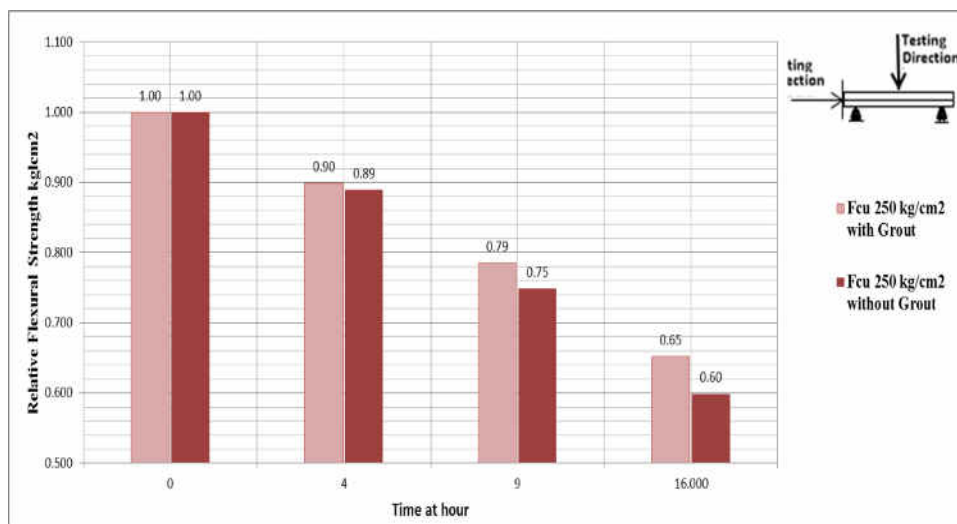


Fig. 9. Relative flexural strength and time with grout and without grout of concrete 250 kg/cm^2

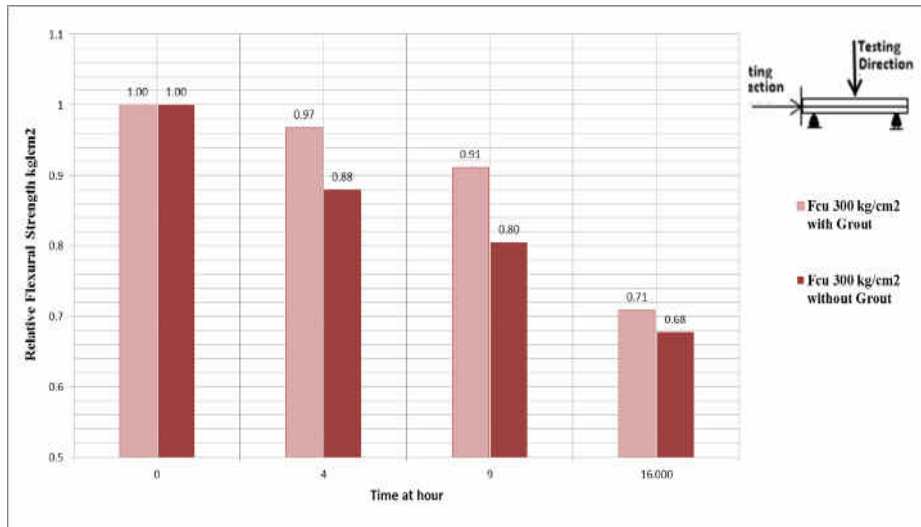


Fig. 10. Relative flexural strength and different delay in time with and without grout of concrete 300 kg/cm²

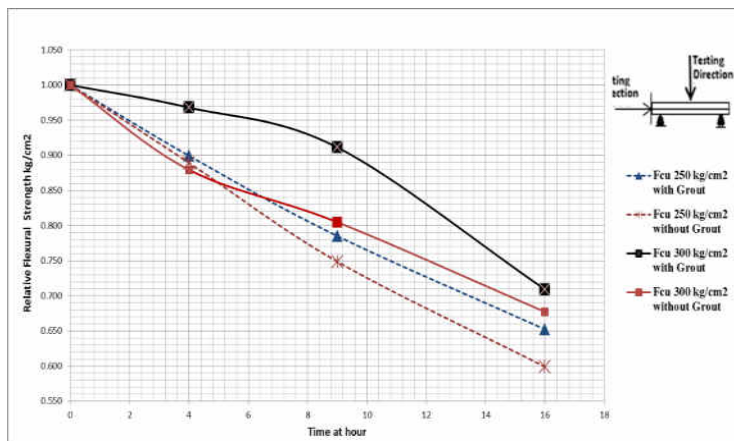


Fig. .11. Relative flexural strength and delay in time with grout and without grout for 250 kg/cm² & 300 kg/cm²

5. Conclusions

This paper presented the mechanical properties of concrete contains cold joint treated with grout and without grout after (4, 9 and 16 hours). The study results are summarized as follows.

- 1- By increasing the time casting the second layer of concrete, the compressive, splitting tensile and flexural strengths of concrete will decrease.
- 2- The use of grout for treat the first layer just before casting the second layer will improve the mechanical properties of concrete.
- 3- The mechanical properties of concrete grade 300kg/cm^2 are more influence than concrete grade 250kg/cm^2 .
- 4- The effect of grout on mechanical properties of concrete appears at 16 hour and has low effect at 4, 9 hour.

6. References

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تأثير الوقت عند صب الطبقة الثانية للخرسانة على خواصها الميكانيكية

الملخص:

فصل الصب الاضطرابي يعتبر من المشاكل التي تواجه عملية صب الخرسانة حيث انه ينتج بسبب التأخير في صب الطبقة الثانية ويحدث ذلك ربما إلى حدوث خلية حديدية ميكانيكية للصب مثل خلطة الخرسانة، الشائنة، الخلطة، المضخة، سيارة نقل الخرسانة والتي تؤدي إلى وقعية الصب مما ينتج عن ذلك تواجد الفاصلا الاضطرابي، وهذا الفاصل يختلف عن الفواصل المعروفة مثل فواصل التمدد والهبوط الذي يراعى المهندس اخذه في الاعتبار أثناء مراحل التصميم والتنفيذ في حين ان الفاصل الاضطرابي لا يمكن التنبؤ بموعد حدوثه او مكانه. لذا، فالهدف من هذا العمل هو دراسة تأثير التأخر في الفترة الزمنية لصب الطبقة الثانية من الخرسانة بعد 4، 9، 16 ساعة لنعلم عن خواص الخرسانة عند قوة ضغط 250 و 300 كجم/سم² وتم دراسة الخواص الميكانيكية للخرسانة التالية مقاومة الضغط، والتشد الغير مباشر والانحناء في الحالات التالية:

اولاً: عند رش الطبقة الأولى من الخرسانة بالماء قبل صب الطبقة الثانية
 ثانياً: عند دهان الطبقة الأولى من الخرسانة بمادة الجروت قبل صب الطبقة الثانية
 وذلك لكل من نوعي الخرسانة 250 و 300 كجم/سم² على حده. وقد اشارت النتائج الى ان استخدام مادة الجروت في طلاء الطبقة الأولى للصب وقبل صب الطبقة الثانية مباشرة له تأثير إيجابي على تحسين خواص الخرسانة الميكانيكية.