*An-Najah Univ. J. Res. (N. Sc), Vol. 17(1), 2003*

# The Effect of Capping Condition on the Compressive Strength of Concrete Hollow Blocks

تأثير نوع التغطية للطوب المفرغ على قوة الضغط المحوري

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*Received: (18/9/2002), Accepted: (25/5/2003)*

## Abstract

One of the quality control tests done on the concrete hollow blocks is the compressive strength. In order to simulate in situ strength of the concrete blocks, capping technique was used in order to achieve smooth perpendicular surface for compressive strength test specimens. Cement Capping is one of the most widely used methods in testing compressive strength of concrete hollow blocks. In this research, other types of capping was used in addition to cement-gyps capping that is wood capping by using of plywood plates on the compressive strength specimens.

Specimens without any treatment for capping were also tested for comparative analysis. Cases of capping (or no capping) were considered for several types of hollow blocks (variable thickness) of 70,100,150 and 200 mm thickness. The results showed that no significant effect of the specimens size on the ratio of compressive strength between no-capping and cement-gyps capping, no-capping and plywood capping, and cement-gyps and plywood capping. The ratio of compressive strength between the cement-gyps and no-capping are approximately equal to the ratio between plywood and no-capping. The correlation established for compressive strength for Cement-gyps capping, and plywood capping was recommended for use interchangeably.

Keywords: concert hollow blocks, compressive strength, capping type, cement-gyps capping, plywood capping.

**ملخص**

يعتبر فحص قوة الضغط المحوري واحداً من أهم الفحوصات على الطوب المفرغ، ومن منطلق فحص الطوب بصورة ناجحة حسب وضعية استخدامها في الواقع فقد تم اللجوء إلى استخدام التغطية لإعطاء سطح مصقول ومتعامد مع ارتفاع العينة. أسلوب التغطية مستخدم في كثير من المواصفات العالمية وعليه فقد تم استخدام خليط الإسمنت والجبص في هذا البحث بالإضافة لاستخدام ألواح الساندويتش الخشبية في فحص الضغط المحوري للطوب المفرغ. بالإضافة لذلك فقد تم فحص الطوب المفرغ بدون استخدام أي تغطية. لحالات التغطية أو عدمها أعلاه، فقد تم فحص عدة أنواع من الطوب بسماكة ٧٠ و١٠٠ و١٥٠ و٢٠٠مم. النتائج أظهرت أنه لا

يوجد تأثير مباشر ناتج عن عرض الطوب على نسبة الضغط المحوري بدون تغطيته، وتغطية باستخدام خليط الإسمنت والجبص وكذلك نفس النسق تكرر في كل من عدم التغطية وتغطيته باستخدام ألواح الخشب وخليط الإسمنت والجبص وألواح الخشب. أما نسبة الضغط المحوري بين تغطية خليط الإسمنت والجبص وبدون تغطيته فقد كانت تقريباً مساوية لنسبة تغطية ألواح الخشب وبدون تغطية. العلاقة التي تم استنتاجها لقيمة الضغط المحوري الناتج من استخدام تغطية خليط الإسمنت والجبص وتغطية ألواح الخشب. فقد تم التوجه باستخدامها في حالة الفحص في أي من النوعين بصورة متبادلة.

## Introduction

Concrete hollow blocks became in recent years as one of the main elements in the construction of building structures. This created a growing interest in the characteristics and method of testing of this product; this interest became at a critical stage of establishing a local Palestinian standard to coop with the vast growth in the construction industry. Each country developed a specific technical standard of its own to define this product in terms of ingredients, characteristics, and method of testing to suit the type of local use.

Manufacturing of concrete hollow blocks and other building products increased drastically in terms of quantity as well as improvement in quality. The number of factories doubled and production jumped to six times that of the mid nineties [1]. In addition, several new types and sizes were introduced for the construction industry. This growth created the need for better quality products, and quality control through a creation of local Palestinian standard. Local quality control laboratories used to adapt different standards in the evaluation of the quality of concrete hollow blocks and in the method of testing. The characteristic of concrete hollow blocks covers shape and finish, dimensions, compressive strength, and density. As far as the method of testing, the effect of capping condition was a debatable issue between using either cement-gyps capping or plywood boards. The first capping condition using Cement-gyps mixture are the standard adapted by American Society of Testing and materials "ASTM" while plywood capping condition is used localy, the effect of each on the compressive strength of concrete hollow blocks was investigated in this research.

### Research Significance

This research was carried out to evaluate the effect of capping condition on the compressive strength of concrete hollow blocks, this strength considered

different types of capping conditions including a no-capping condition, Cement-gyps capping, and plywood capping.

Results obtained in this research would be useful to support the improvement of the Palestinian standard "PS 6 Part 1 Block–Concrete Blocks for Walls "[2]. It will also avoid the problems associated with the use of traditional capping of Cement-gyps mixture such as the delay time needed to prepare the sample for compressive strength testing, and the difficulty of having a smooth and parallel surface which usually requires several trills and highly skilled technicians.

## Literature Review

The purpose of specifying end conditions requirement of plainness and perpendicularity are to achieve a uniform transfer of load to the test specimen. Surface irregularities will lead to local concentration of stress, as well non-perpendicular ends, even in specimens that are capped to meet the specified requirement [3].

Since very little research have been done on Concrete hollow blocks specially in the last twenty five years [4-8] non of this research focused on the effect of capping and capping materials on the compressive strength of Concrete hollow blocks, while the effect of cylinder end condition prior to capping on strength test results has been reported by several authors [9-12]. In general, specimen end that do not meet the specified requirements prior to capping cause lower strength test results, and the degree of the strength reduction increases for higher strength concrete.

Several capping materials are introduced for concrete specimens (fresh or hardened, molded or cored) amongst are Cement paste, sulfur mortar, and high strength gypsum. But in general, the requirement on capping materials and procedures are meant to eliminate possible detrimental affect of caps on strength test results, since, depending on the capping method used, either lateral compression or tension may be introduced into the specimen end due to differences in lateral deformation of the capping material and the concrete under load [13]. Many capping procedures have been proposed and much research conducted to study the effect of different capping materials and methods on compressive strength test results [5-8, 14-15]; the results of these studies has been the development of ASTM C 617 as it currently exists. In general, the research on concrete specimens indicated that strength test results are highly dependent on properties of specimen capping. Weak caps or those that are allowed to

expand laterally under load cause reductions in apparent specimen strength. These effects are more pronounced as the level of concrete strength being tested increased.

Currently, the use of additional capping methods is being widely investigated [4, 16- 20]; a task group within ASTM Subcommittee C09.03.01 is examining its use as a proposed standard capping method [21].

In this research, a comparative study will investigate the use of Cement gyps relative to that of using plywood boards for capping.

## Methodology

The effect of capping condition on compressive strength for concrete hollow blocks was investigated using four types of hollow blocks having the same mix proportion. Specimens are manufactured, cured, and stored in a standard condition at a local block production factory in accordance to the Palestinian Standards 'PS 6". The four types of concrete hollow blocks considered in this research with an overall thickness of 70, 100,150, and 200 mm, length and high of all specimens kept constant at 40 mm and 20 mm respectively. Three specimens were tested for each type of capping condition which is mainly; no capping, Cement-gyps capping, and plywood board capping, the no-capping was taken into consideration for comparative analysis. In addition, three specimens for each type of thickness were tested which brings the total number of specimens for each thickness type to one hundred and twenty, and the grand total for all thickness types to three hundred and sixty specimens.

Each set of specimens designated for Cement-gyps capping were prepared according to Palestinian Standards "PS 6" as follows:

1. A paste was prepared which consists of one third Portland Cement to two thirds gyps by weight to a reasonable consistency.
2. Paste was laid on a level, smooth, and non-permeable surface such as glass plate.
3. The topside of the specimen was placed over the paste prepared as in step "b" above and left to harden, the same procedures were repeated for the other compression side.

Specimens prepared using this procedure were left for at least twelve hours and loading surface was checked using water level before testing.

Finally, all specimens with different capping conditions were tested for compressive strength at age of twenty-eight days in according to the requirements of Palestinian Standards "PS 6 Part 1".

**Results and Analysis**

For analysis purposes, three terms were considered as presented in equations 1, 2, and 3.

$$\mathbf{P1} = \frac{B-A}{B}[100\%] \quad \text{..... Equation (1)}$$

$$\mathbf{P2} = \frac{C-A}{C}[100\%] \quad \text{..... Equation (2)}$$

$$\mathbf{P3} = \frac{B-C}{B}[100\%] \quad \text{..... Equation (3)}$$

where:

A= Compressive Strength of concrete hollow blocks with no-capping condition.

B= Compressive Strength of concrete hollow blocks with Cement-gyps capping.

C= Compressive Strength of concrete hollow blocks with plywood capping.

Based on the obtained results, a correlation between the strength of each type of concrete hollow blocks for the different capping conditions were established. The linear regression was considered to best fit the data as indicated by the curve equation relating each set of variables. In addition, each curve equation is presented by its regression fitting ($R^2$).

In the analysis of the relation between the strength of concrete hollow block having Cement-gyps capping and those with no-capping condition as presented in Figure 1, it is clear that linear regression can best describe this relation. It can be seen as the concrete block thickness increases the slope that expresses the relation increases indicating a closer gap between the values of compressive strength resulted from using the two types of capping conditions. This can be easily explained by the thickness width ratio, it is very well known as this ratio increases the overall strength for the same concrete increases. In addition, values of compressive strength for Cement-gyps capping condition are always higher than those values of no-capping condition. This is expected since the no capping condition creates concentration of stresses on the loading surface

aggregates which eventually creates a propagation of cracks throughout the specimen which will cause early failure. For low compressive strength range and smaller block thickness, higher difference exists between the different thickness compared to high compressive strength blocks. For example at 4 MPa compressive strength for the no-capping condition, the difference between 70 mm and 200 mm block thickness is +3 MPa while at 8 MPa compressive strength for no-capping condition the difference is –3 MPa for the same block thickness. It can be noticed that no simple correction factor can be adapted in this case, in addition to the fact that the no capping condition is not recommended due to high variability of loading surface texture of the finished concrete block. In general, it is worth to mention the fact that surface texture are highly affected by the nominal maximum aggregate size used in the mix.

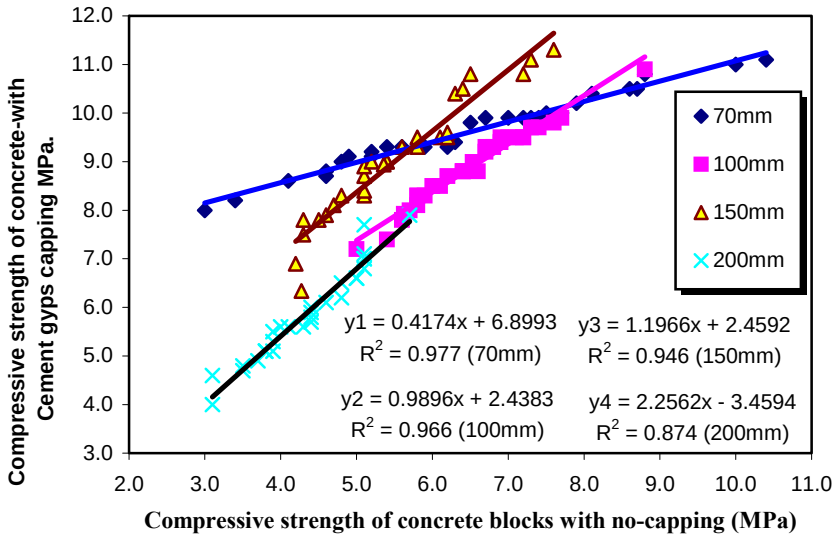


**Figure 1:** Relationship of the Compressive Strength of Different Types of Concrete Hollow Blocks Having Cement-gyps Capping and No-capping Condition.

In the analysis of the relation between the compressive strength of concrete hollow blocks using plywood for capping and that of no-capping condition as presented in Figure 2, it is clear that in this case too, the linear relationship is best to fit the obtained data. In this case, a more consistent relationship exists between the different thickness, it can be seen as the block compressive strength increases, the rate of strength increase are consistent regardless of thickness

with the exception of the 200 mm blocks. Also as the block thickness increase the difference in compressive strength increases, this is consistent for all ranges of compressive strength. It can be noticed that values of strength for plywood capping of concrete blocks are always higher than those blocks of no-capping condition. This is because larger area of the block surface is loaded during compressive strength testing using plywood boards for capping. In another word, the affect of surface texture is reduced to a great extent due to the impediment of surface aggregate into the plywood board allowing more block surface area to be loaded during compressive strength testing and eventually giving a better idea of the actual compressive strength. In this case too, no simple correction factor can not be introduced to convert values of compressive strength from one type of capping to another nor it is recommended to be used for the reasons mentioned earlier.

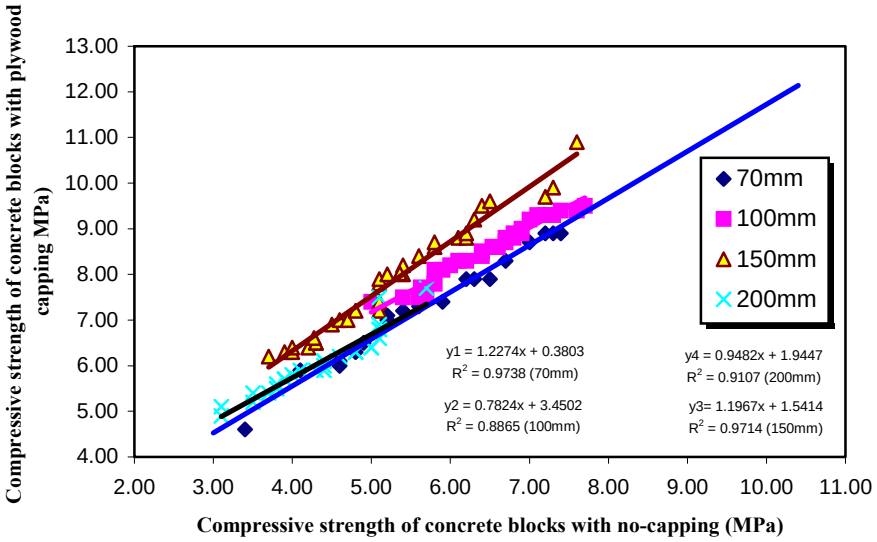


**Figure 2:** Relationship of the Compressive Strength of Different Types of Concrete Hollow Blocks Having Plywood Capping and No -capping Condition.

In the analysis of the relationship of compressive strength of concrete hollow blocks using Cement-gyps capping and that of plywood capping as presented in Figure 3, the linear relation can best describe this relationship too. Generally, it can be seen with the exception of the 70 mm concrete blocks as block thickness increases the difference in compressive strength between using Cement gyps capping, and plywood capping decreases, also generally, as block

thickness increase the rate of compressive strength increase. This is consistent for all types of block thickness.With the exception of 200mm concrete block thichness, it can be seen also that values of compressive strength for Cement-gyps capping are generaly higher than that of the compressive strength of plywood capping which clearly indicates more of surface area being loaded during compressive strength testing which reflects more representative picture of the compressive strength of the concrete hollow blocks. In this case, though there is no simple correction factor can be used to convert one compressive strength for each type of capping to another, but the linear equation drawn for each block thickness can be used to make this conversion as shown in Figure 3. For example, a 10 MPa compressive strength for a 70 mm concrete hollow block specimen using Cement-gyps capping material are equivalent to 8.94 MPa compressive strength using plywood for capping for the same specimen tested.

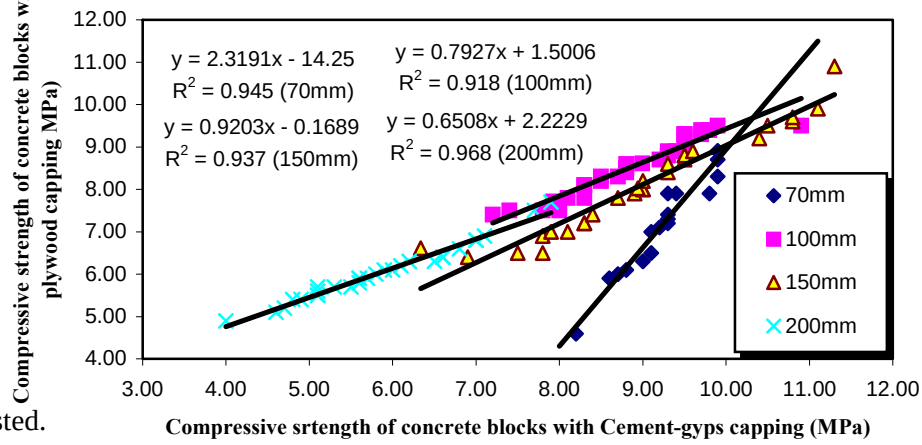


**Figure 3:** Relationship of the Compressive Strength of Different Types of Concrete Hollow Blocks Having Cement-gyps Capping and Plywood Capping.

In order to have an assessment of the effect of each type of concrete hollow block capping condition relative to the other; three terms were introduced as stated earlier. In the analysis of concrete hollow blocks with no-capping condition relative to that Cement-gyps capping condition, P1 values are presented in Figure 4. Refereeing to concrete block thickness of 70 mm, their is sharp decrease of P1 value relative to the other thickness as a result of relatively small change in strength, this sensitivity in the value of P1 indicates that the concentration of stresses on the loading surface aggregates creates or propagates cracks in the specimens of no-capping much faster than that in specimens

capped with Cement-gyps paste, to a lesser extent, the same happened to the concrete block thickness of 100, 150, and 200 mm, this is due to the contribution of the third dimension failure plan (higher width-length ratio). In the analysis of concrete blocks with no-capping condition relative to that of plywood condition, P2 values are presented in Figure 5, it can be seen that same behavior exists as in P1 as shown earlier with a slight change in the slope of the curves. For all types of concrete hollow blocks presented in this figure, as compressive strength increases, the difference in strength decreases.

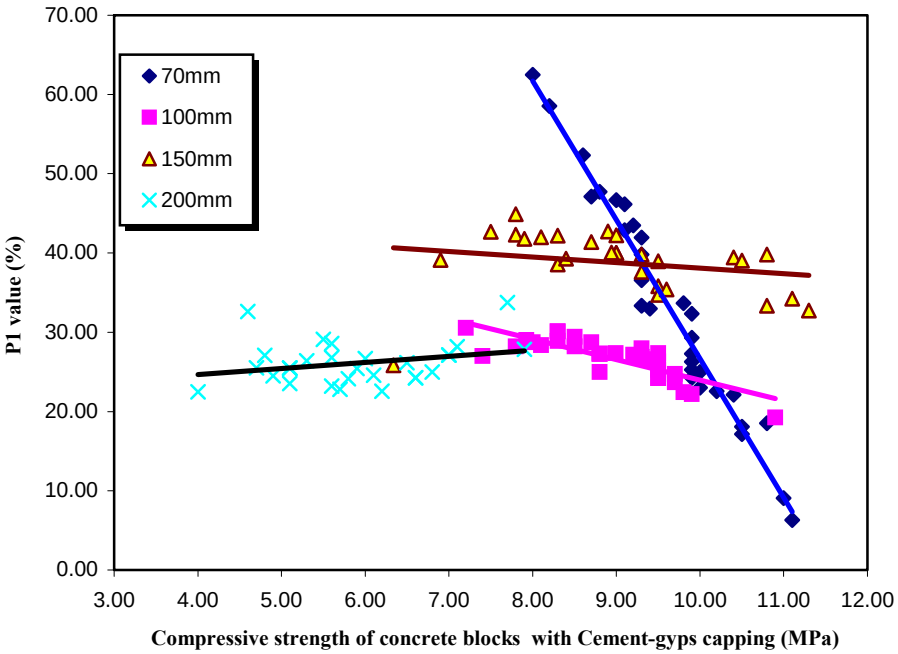


**Figure 4:** Relationship of Compressive Strength of Different Types of Concrete Hollow Blocks with Cement-gyps Capping and P1 Value.

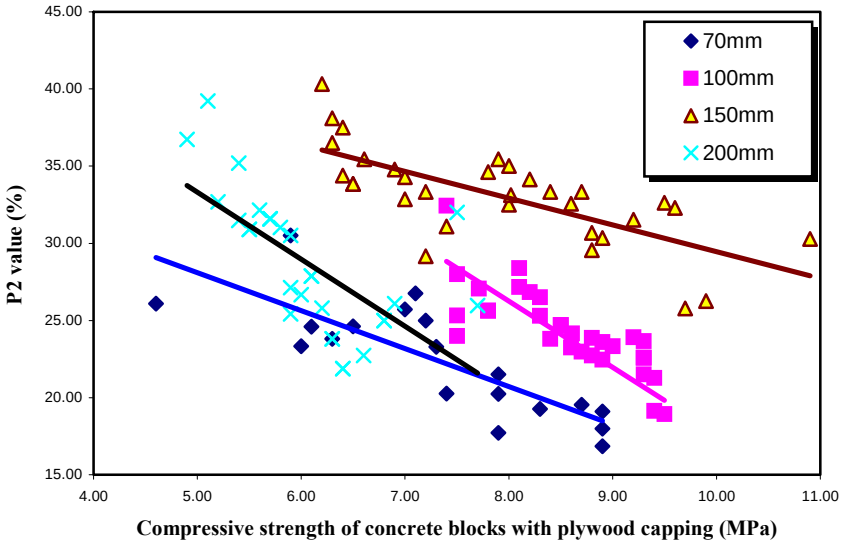


**Figure 5:** Relationship of Compressive Strength of Different Types of Concrete Hollow Blocks With Plywood Capping and P2 Value.

In the analysis of the concrete block with plywood capping relative to Cement-gyps capping, P3 values are presented in Figure 6. Referring to curves for concrete block thickness of 70,100, 150, and 200 mm, it can be noticed as the concrete block compressive strength for ply-wood capping increase the values of P3 for all block thickness slightly increase or decrease relative to P1 and P2 values, this indicates that differences in compressive strength between Cement-gyps and plywood capping narrows gradually (taking Cement-gyps as a reference) which eventually indicates a slight difference in compressive strength between using either Cement-gyps capping or plywood capping.

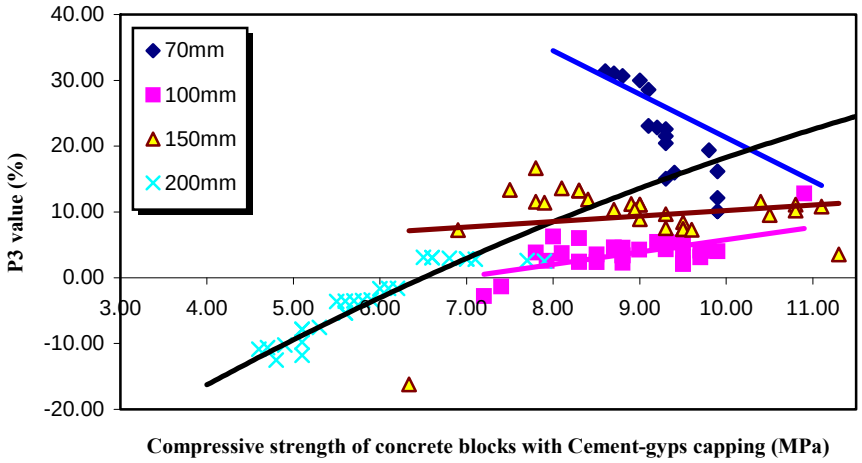


**Figure 6:** Relationship of Compressive Srength of Different Types of Concrete Hollow Blocks With Cement-Gyps Capping And P3 Value.

## Conclusions and Recommendations

Based on the obtained data and the analysis above, the following conclusions and recommendations are considered valid:

1. Concrete hollow blocks should not be tested without a type of approved capping technique.
2. Testing Concrete hollow blocks for compressive strength can be done using either Cement-gyps or plywood as a capping material.
3. Their exists no simple correction factor to relate compressive strength values of concrete hollow blocks tested using Cement-gyps or plywood as a capping material.
4. The linear correlation equation drawn as apart of this research can be used to convert compressive strength values for concrete hollow blocks capped using Cement-gyps to those specimens capped using plywood boards.
5. It is recommended to further study other forms of capping materials for compressive strength testing such as rubber boards…etc.

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