Structural and Economic Comparisons Between the Conventional and Stacking Method of Laying Locally Manufactured Non-Load Bearing Concrete Hollow Blocks (CHBs)*

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Abstract

One structural element in constructing a building which requires lengthy execution is the construction of peripheral walls and partitions. If the duration of this activity is lessened, the total construction time will surely be shortened, and somehow, a cut in the construction expense due to the subsequently saved time shall also be realized.

This study presents an analysis of the effects of deviating from the conventional way of laying concrete hollow blocks with the proposed stacking method using locally manufactured concrete hollow blocks.

The general trend of the study suggests that the proposed stacking method of laying locally manufactured concrete hollow blocks could save an average of 39 seconds per square meter, and considerably more as the wall progresses in height. Using this statistics, a medium rise building with 1,500 sq.m. of wall area could save two man-days with the method.

The test results show that the samples laid using the stacking method are generally stronger than the samples done with the staggered method in terms of the recorded higher compressive stresses by direct comparison. When compared vis-à-vis the age, the staggered method was observed to have resisted slightly more (but insignificant) compressive stresses than the samples in stacking method.

Introduction

Too much adherence to the conventional practice of construction implies the lack of creativity and initiative of local construction workers in devising ways and means to vary their adopted methodology. This attitude impends the dynamism and innovativeness of young engineers. Although time is always inseparable among

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contracts, contractors seem to take it for granted, leaving behind the unsatisfied **and** complaining project owner due to the delay in the completion of the project resulting to an increase in overhead costs Time consciousness is one thing our local contractors and construction workers miss in their project management.

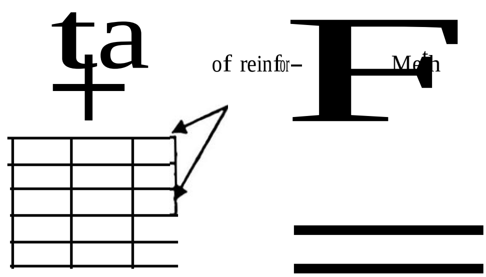
Objectives of the Study

This study attempted to compare structurally and economically two methods of laying concrete hollow blocks: a) staggered or otherwise called conventional, and b) stacking. (Sec Figure I) In the stacking method, the blocks arc laid and piled one over the other, leaving a trace of vertically straight line caused by the edges of the uniformly sized blocks.

Structural comparisons between the two methods of laying concrete hollow blocks would entail analyzing the strengths of both samples by subjecting them to gradually applied loads to determine their maximum compressive stresses.

The economic comparisons necessitate a thorough analysis of the time spent in constructing both samples. After which, the difference in the consumed time shall be translated into equivalent man-hours to compute the resulting savings in time using the method.

Seemingly, this study might not be an outright innovation, neither could it supply brand new information about an engineering concept, but the initiative that it aimed to portray could be replicated to inject changes into our existing stock of engineering knowledge.



(a0) (b)

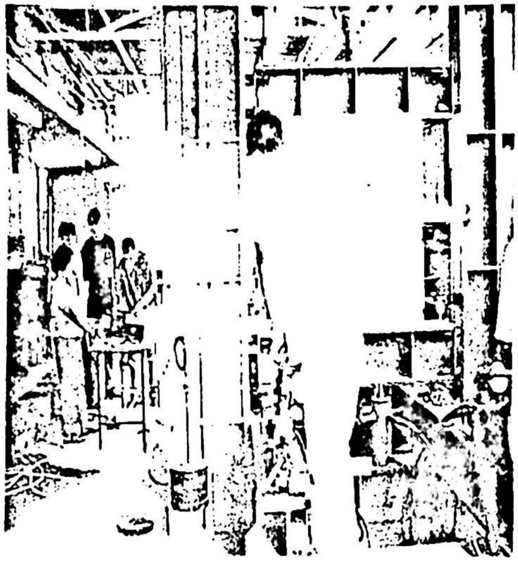
Fig. 1. The stacking (a) and staggered (b) methods of laying concrete hollow blocks

Research Design and Methodology

This study used the experimental-descriptive type. Three samples each in the staggered (conventional) and stacking (proposed) methods of laying hollow blocks were made using 6" and 5" thick masonry wall, I meter by I meter.

The economic comparison was done by time-motion analysis. The actual time spent by a team of construction workers in preparing the samples laid using the staggered and the stacking methods was recorded. The difference in time of constructing the samples with the two methods was the basis of computing the savings in the labor cost.

On the other hand, the structural comparison was undertaken from the results of strength gauges noted by subjecting the samples to gradually applied loads using the loading frame.



A typical set-up of the CB samples in the conduct of testing at the TUP CE laboratory.

The testing of the samples was done at the Technological University of the Philippines, Manila. Like reinforced concrete, the strength of the filled and grouted cells of the hollow blocks is gradually attained **as it** ages, thus the researchers assumed the samples to have attained their full strength within 28 days upon grouting and filling. The testing of the samples was done after the 28" day.

Analysis of the Results

a. Time-Motion Comparison

One team of workers was utilized in constructing the samples, one mason and two laborers. As each sample was constructed, the time consumed (see lliable I) to construct each sample was recorded, as follows:

As shown in Fig. I, the STG (staggered) and STK (stacking) samples were one-meter by one-meter, reinforced with four- 10mm diameter bars laid 0.60 m apart, both ways, leaving 0.20m all-around clearance. Horizontal bars were laid above the first and fourth layers.

Table 1. Observations in the construction time for the staggered and stacking samples.

Sample ID	**Const'n Time (in minutes)**	**Sample** ID	**Const'n Time (in minutes)**	**Difference** in Time **(sec)**	**Remarks**
STG II	29.0	STK 11	28.5	30	STG>STK
STG 12	27.0	STK 12	27.0	0	STG=STK
STG 13	28.0	STK 13	27.0	60	STG>STK
STG21	27.0	STK 21	28.0	-60	STG<STK
STG 22	26.0	STK 22	25.0	60	STG>STK
STG 23	26.0	STK 23	25.5	30	STG>STK
STG 31	25.0	STK 31	24.5	30	STG>STK
STG 32	25.S	STK 32	24.8	42	STG>STK
STG33	26.0	STK33	25.5	30	STG>STK
STG41	26.5	STK41	26.0	30	STG>STK
STG 42	25.0	STK 42	25.0	0	STG=STK
STG43	24.5	STK43	*25.5*	-60	STG<STK

The difference in the construction time for both samples is almost negligible (30 seconds at most, or 39 sec average), but the general trend is that more time is consumed in the construction of the staggered style of laying hollow blocks than those laid by the stacking method.

In the stacking sample, a bar coincided with the ends of two interconnecting blocks. Thus the mason need not raise the blocks up to the height of the bar to position them. There is time saved by not raising the blocks to fit the bar within a hole of the block. For the staggered samples, all blocks were raised up to the height of the reinforcing bar. Raising every block can consume more time especially when the height of the bar would be higher than one meter.

The above observation implies that with the stacking method continuously done in a project, a considerable amount of time could be saved. The difference in time, as reflected from the samples, was not so significant because the height of the samples was just one-meter, but could become considerable for higher walls. I£ 39 seconds could be assumed to gauge the saved time per square meter of wall, then, more or less, in a building where there is 1,500 sq.m. of wall area, then 58,500 seconds or 16.25 hours (2 man-days) could be saved. Two man-days could be utilized for more advance activities.

b. Structural Analysis

o Compressive Stress Comparison

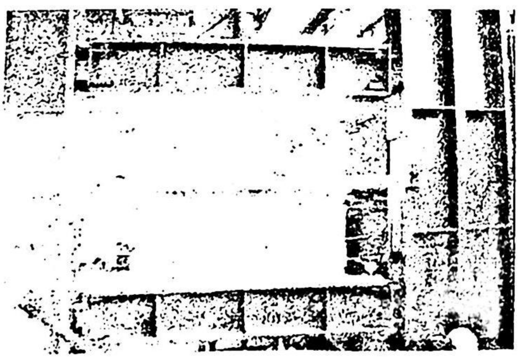
Based on the actually graphed load-deformation behavior of each sample when subjected to gradually applied loads, the following (refer to Table 2) are the results of the comparison.

Samples marked with "STG" represent samples constructed with the conventional or staggered method of laying concrete hollow blocks, while those marked with "STK" are those constructed adopting the stacking method. To every STG, there is a corresponding STK.

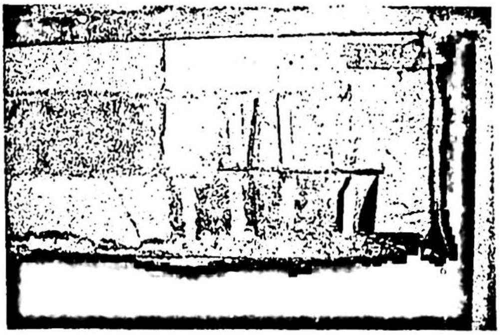
Nine comparisons of the 6 in. thick hollow blocks were made. Results show (see Table 2) that among the nine samples compared, four stacking samples registered higher compressive stresses than the conventionally constructed samples. One stacking sample registered the same stress as its counterpart, while four stacking samples registered lower compressive stresses than their staggered counterparts.

Table 2. The computed maximum stresses of the 6 in. samples in the staggered and stacking methods

STG ID #	**Computed Stress**	**Cause of Failure**	**STKID** #	**Computed Stress**	**Cause of Failure**	**Increase/ Decrease in** Stress	**Stress Comparison**
1	3.05 MPa	CHB	STK 11	3.24 Ma	CHB	5.7%	STK>STG
12	3.82MPa	CHB	STK 12	4.03 MPa	CHB	5.0%	STK>STG
13	3.18 MPa	CHB	STK 13	3.52 MPa	CHB	9.6%	STK>STG
21	4.53 MPa	CHB	STK21	4.53 MPa	CHB	-	STK=STG
22	4.52 MPa	CHB	STK22	6.12MPa	CHB	26.2%	STK>STG
23	3.84 MPa	Rebars	STK23	3.77 MPa	CHB	-1.7%	STK<STG
31	4.93 MPa	CHB	STK31	4.31 MPa	Rebars	-14.3 %	STK<STG
32	5.70MPa	CHB	STK32	4.IOMPa	Rebars	-18.9%	STK<STG
33	5.47MPa	CHB	STK33	3.62MPa	Rebars	-45.1%	STK<STG
Average Compressive Stress		STG 4.34MPa		STK 4.14MPa			



The causes of failure were also noted. It was seen that STGs and STKs 11, 12, 13, 21, 22 and STK 23 failed because of the CHB. STGs 23, STK 31, 32 and 33 failed because the reinforcing bars buckled first, forcing the concrete hollow blocks to break. If not due to the reinforcing bars which failed first, the CHB could have sustained higher compressive stresses, just like those of STKs 11, 12, 13, 21, 22 and 23.



The cause of failure of STG 23 and STKs 31, 32 and 33 was the reinforcing steel. The reinforcements buckled forcing the concrete hollow blocks to break.

For the 5" thick CHB samples, the STKs were able to resist higher compressive stresses than their STG counterparts. The results of the tests are shown in Table 3.

Table 3. The computed maximum stresses of the 5-in samples in the staggered and stacking methods.

STG ID #	Stress	Cause of Failure	STK ID #	Stress	Cause of Failure	Increase/ decrease in stress	Stress Compa-rison
41	2.54 MPa	CHB	41	3.27MPa	CHB	22.2%	STK>STG
42	2.68 MPa	CHB	42	3.13 MPa	CHB	14.3%	STK>STG
43	2.61 MPa	CHB	43	3.04MPa	CHB	14.3%	STK>STG
Average Compressive Stress		STG 2.61 MPa		STK 3.15 MPa			

The unfilled, ungrouted concrete hollow blocks, taken from the same manufacturer, were also tested for compression (refer to Table 4).

The computed compressive stresses of the unfilled, ungrouted 6" and 4" CHBs show that the CHBs were rather low compared to the theoretically allowable compressive stress of 2.42 MPa (350 psi) for non-load bearing hollow blocks. As further gleaned from Table 2, with the computed average compressive stress, the grouted 6" STGs were 1.86 times stronger than the ungrouted 6" CHB, while the STKs were 1.78 times stronger than the ungrouted samples.

On the other hand, with the computed average stress of the grouted 5" STG samples the 5" ungrouted CHBs were made 5.33 times stronger when grouted, while 6.43 times stronger when grouted with the stacking method.

Table 4. The maximum compressive stresses of the ungrouted, unfilled concrete hollow blocks.

Sample ID	Ave thick-ness, cm	Ave length, cm	Ave width, cm	Compressive stress	Average Compressive Stress
A-l	12.33	40	18.5	0.64 MPa	0.49MPa
A-2	12.25	35	19.0	0.39MPa	
A-3	12.37	40	19.0	0.44MPa	
B-1	14.20	39	18.2	1.23 MPa	2.33 MPa
B-2	14.15	37	17.8	2.49MPa	
B-3	13.33	34	19.0	3.28 MPa	

Likewise, samples of the reinforcing bars used in the wall specimens were' also tested for comparison. For both methods of concrete hollow blocks laying, IO mm diameter and I-meter long reinforcing bars were used. Table 5 shows the results:

Table 5. The maximum tensile stresses of the 10 mm diameter reinforcing bars.

Sample ID	Length, cm	Weight, kg	Ave. Diameter, mm	Observed Elongation, mm	Computed tensile stress, MPa	Average Tensile Stress
1	110.2	581.20	10.13	50.2	333.29 MPa	300.41 MPa
2	100.5	584.30	10.07	49.0	289.58 MPa	
3	100.3	584.50	10.05	50.6	278.37 MPa	

The seeming variation of the utilized reinforcing bars in the study should justify the several cases of samples with the steel support failing first. While there are ordinary steel bars with high yield stresses (Sample I of Table 5), there are also steel bars purchased in local hardware stores that are rather low in tension (Sample 3, same table).

o **Strength of Samples Vis-a-vis their Age**

To further analyze the samples, their ages were recorded to investigate the resistance offered by the samples when subjected to the loads. The following graphs describe their behavior vis-a-vis their age.

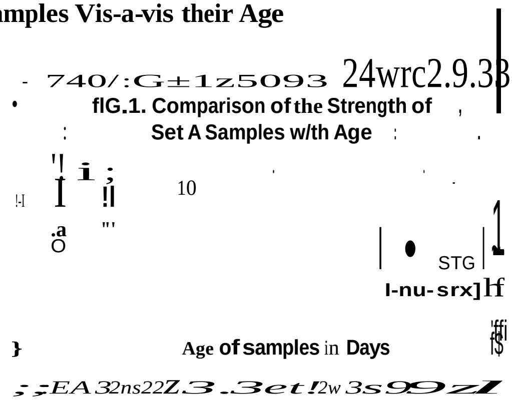


fIG.1. Comparison of the Strength of Set A Samples w/th Age

Three sets of the samples constructed on three different dates were analyzed. Set A was undertaken by pairing STG 11, 21 and 31 with STK 11, 21 and 31. On the 103" day, the STK sample registered a higher compressive stress than its STG counterpart. On the 109 and 113 days, the STK sample registered more compressive stresses than the STG counterparts. Refer to Figure I.

For the second set of samples (Set B), the STK registered a higher compressive stress than its STG partner during the 103" and 113 days. The STG sample was higher in compressive stress than the STK counterpart. Figure 2 shows the comparison. The paired samples were STGs and STKs12, 21 and 32 with their ages noted and plotted against the observed corresponding compressive stress.

Fig. 2. Comparison of the Strength of Set B Samples vis-a-vis their Age

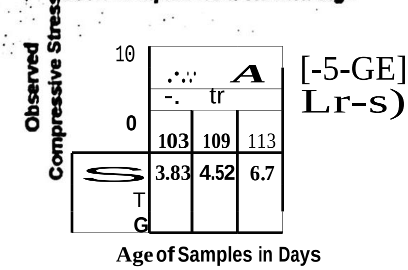
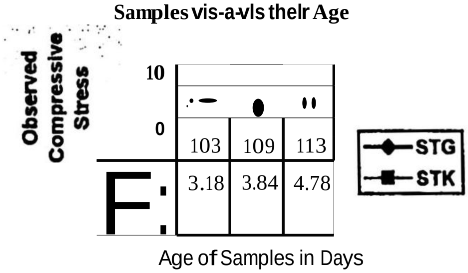


Fig.3. Comparison of the Strength of Set Samples vis-a-vis their Age



The third set of samples (Set C) STGs and STKs 11, 21 and 31 were observed to have the recorded compressive stresses in Figure 3. On the 103" day, the STK sample's compressive stress was higher than its STG counterpart. On the 109 and 114 days, the STG samples had slightly higher compressive stresses.

On the overall, the following table synthesizes the findings. Figure 4 presents the summative view of the average stresses.

Fig.4. Comparison of the Strength of All Samples vis-a-vis their Age

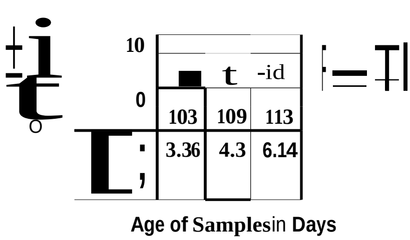
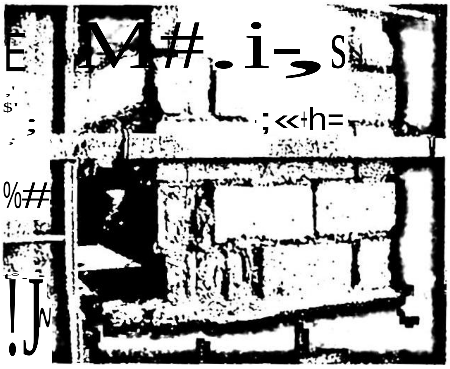


Table 6. Average compressive stress of the samples vis-a-vis their age.

Sample Category	Age of Samples in Days		
	103 days	109 days	113 days
STG	3.61 MPa	4.57MPa	5.14 MPa
STK	4.13 MPa	4.53 MPa	5.07MPa
Difference in Stress	0.52 MPa	-0.04 MPa	-0.07 MPa



For concrete hollow blocks with low starting compressive stresses, the strength of the grouted blocks would not be offset by the strong mixture of the grout.

From the average value of the compressive stresses, there were minimal differences between the observed computed stresses of the stacking and staggered methods of laying hollow blocks.

Summary of Findings

The following findings are noted:

1. An average savings in construction time at 39 seconds per square meter, and a projected increase in time savings for higher walls;
2. A strong mixture to grout concrete hollow blocks cannot compensate the low compressive stress of ungrouted hollow blocks to be used;
3. The 6" ungrouted CHB increased strength by 1.86 times when grouted with the staggered method, while 1.78 times with the stacking method. The ungrouted 5" CHBs increased strength 5.3 times with the staggered method, while 6.43 times with the stacking method;
4. There are insignificant differences in the computed average compressive stresses between the STG and STK samples on Day 103, Day 107 and Day 113. This suggests that the strength of the stacking sample was comparable to the staggered sample, if not even higher, if it were not due to the steel reinforcement that failed first.

Conclusion

In the light of the foregoing discussions and findings, the conventional method of laying hollow blocks, otherwise called the staggered method, may not be the ultimately best method of laying locally manufactured non-load bearing concrete hollow blocks. The stacking method of laying concrete hollow blocks offers considerations from the standpoints of economy and performance.

With the stacking method, a conservative time savings of 39 seconds per sq. m. at ground level was observed. More time savings could be realized as a partition progresses in height. Such savings in the handling and installation time could be translated into corresponding decrease in the labor expense, and consequently, a cut in the indirect costs.

The performance of the stacking CHB samples is comparable, if not even stronger than the staggered method.

Recommendations

With the findings and conclusions realized, the following are the recommended plan of action:

1. More experiments should be undertaken to determine the resistance of the stacking method against lateral loads before recommending the method for low-cost housing.
2. The strength of the filler should be equal to the strength of the CHB to be used.
3. To optimize the use of concrete hollow blocks as construction materials, another study should be devoted to detennine the CHB rigidity so that they could be assigned loads appropriately.

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