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Price Modeling Of The Non-Load Bearing Concrete Hollow Blocks (CHBs) Manufactured In Ilocos Sur

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***Abstract*— In this study, non-load bearing CHBs were bought as samples from sixteen (16) towns chosen at random from manufacturers, eight (8) of which were selected from the First District and another eight (8) from the Second District of Ilocos Sur. The findings are: the samples were smaller than the recommended standard; from the variables compared, only the thickness and strength parameters were significant in influencing the price of the commodity being studied; the strength of the samples were lower than the minimum specified strength of 2.07MPa; no significant difference between and among the sizes, strengths and distance of the quarry site from the place of production exist; CHBs are more frequently sold on delivery mode; and strength and price have significant relationship.**

A linear mathematical model, Y =3.836+0.748fc'+0.92t was developed to calculate the price of concrete hollow blocks resulting from a regression analysis, where: Y is the delivery price of the CHB, fc' is the compressive strength of the CHB produced, t is the thickness.

In conclusion, CHB manufacturers set a uniform price for their products to be competitive, without considering the quarry site distance and strength. Only 41.1% of the variance were identified in this study.

Future researches may explore the remaining 58.9% of the variance for a rational pricing of CHB products; adherence by manufacturers to the prescribed sizes and strength of CHBs and more strict monitoring by concerned agency to the identified concerns be addressed.

Keywords*— *Price Model, Concrete Hollow Blocks, CHB, cement-gypsumum,

1. INTRODUCTION

One of the major concentrations of research and development (R&D) efforts set by the Department of Science and Technology in its 2010-2016 Investment Plan is manufacturing and production, which calls for the introduction of new materials for production using indigenous and other local materials. In the construction industry, this priority could be translated further in the review of present building methods to come up with cost saving tools and procedures.

Concrete hollow blocks (CHBs) consist one major component of any building. Since its introduction which have minimized the use of clay tiles, many have preferred the use of CHBs due to the ease of their production, inviting more entrepreneurs to engage in this business.

It has become a general observation among the buying public that non-load bearing concrete hollow blocks (CHBs) manufactured from local suppliers in Ilocos Sur are weak to resist even for slight forces only. This was proven scientifically to be true from the results of compressive strength tests of several

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samples of concrete hollow blocks from various manufacturers in Ilocos Sur (Amistad, et. al, 1996).

It is common knowledge in the construction industry that hollow block sizes in the Philippines have one common lateral area, that is, 20 cm. (8 inches) wide and 40 cm. (16 inches) long. http://engineeringtraining.tpub.com/14069/css/14069_275.htm (Accessed March 2, 2015). They vary only in thickness, now commonly to 10 cm. (4 inches) and 12.5.cm. (5 inches). The 15-cm. (6- inch) thick size is only manufactured by order (Integrated Publishing in Construction Management, 2015). This is also taught in the civil engineering technology subject and reinforced in construction estimating books.

There are two common types of laying non-load bearing concrete hollow blocks in the locality, namely, the staggered and the stack bonds. Staggered laying is done by alternating the placement of joints, on the other hand, stack bond is aligning the blocks vertically over the other blocks so that edges form a straight line (Builderbill Graphical Construction Glossary, 2015).

Koksal, H.O. et. al (2005) found out that the compressive strength of concrete block mainly depends on the mix composition (in particular binder content), the degree of compaction, and to a lesser extent on the aggregate type and curing normally used. In general, for a given set of materials, the strength of concrete block will increase with its density. The magnitude of such movement to varying degree is largely influenced by the constituent materials (mainly the aggregate), mix proportions and the process of block manufacturing adopted (Ganesan, T. P., 1992).

In order to simulate in situ strength of the concrete blocks, Abaza, O.A. and Salameh, A.A. (2003) experimented on the significant effect of capping technique on the compressive strength test of concrete hollow block 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 were used in addition to cement-gypsum 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 specimen size on the ratio of compressive strength between no-capping and cement-gypsum capping, no-capping and plywood capping, and cement-gypsum and plywood capping. The ratio of compressive strength between the cement-gypsum and no-capping is approximately equal to the ratio between plywood and no-capping. The correlation established for compressive strength for cement-gypsum capping, and plywood capping was recommended for use interchangeably (Ablaza, et al, 2003). In this research, the capping technique adopted was the use of sulphur.

This study tries to develop a rational approach in pricing concrete hollow blocks (CHB) that would consider important factors involved in the industry: a) the manufacturer with the invested resources, b) the distance of the quarry source to the place of production, c) the pick-up and delivery prices, d) the strength of the manufactured CHBs, and e) the buying public to enjoy the price for every CHB product bought

The research focused on the costing of concrete hollow blocks manufactured in Ilocos Sur in Northern Luzon, Philippines considering the strength and thickness of the blocks, as well as distance where the aggregates are hauled to the place of production. The lengths, widths and thicknesses of the CHBs were measured to describe their physical properties. From the results of the investigation, the study further proposes a model that would profit the manufacturer and at the same time satisfies the consumer. The model could serve as a monitoring and evaluation tool to regulate the manufacture and sale of the said concrete product.

2. OBJECTIVES

The highlight of the research was an analysis of the costing of concrete hollow blocks manufactured in Ilocos Sur, considering the strength and thickness of the blocks, as well as distance where the aggregates are hauled to the place of production. The lengths, widths and thicknesses of the CHBs were measured to describe their physical properties. From the results of the investigation, the study further proposes a model that would profit the manufacturer and at the same time satisfies the consumer. The model shall serve as a monitoring and evaluation tool to regulate the manufacture and sale of the said concrete product. Specifically, the study looked into the following:1) the physical characteristics of the non-load bearing concrete hollow block samples; 2) the significant difference between and among the: a) pick-up and delivery prices of CHBs per town; and b) the delivery prices of the CHB samples; 3) the significant relationship between the a) delivery prices and the distance of the quarry source to the place of production; b) the delivery prices and the compressive stresses of the concrete hollow blocks; c) the compressive strengths of the concrete hollow blocks; and d) the delivery price and the thickness of the blocks; and 4) the suggested pricing scheme to consider the strength, thickness and distance of quarry from the place of production.

3. METHODOLOGY

The descriptive type of research was adopted. To describe the CHB samples, their dimensions were measured and compared by using a standard specification by the Bureau of Product Standards of the Department of Trade and Industry (DTI-BPS) as the point of comparison, distances from the quarry sites of aggregates to the manufacturers' respective places of production were measured, pick-up and delivery prices were gathered and compared, compressive strengths were taken by subjecting them to the Universal Testing Machine at St. Louis University Civil Engineering Laboratory, Baguio City, an accredited testing center in Northern Luzon. Testing procedures were in accordance with ASTM C140-11a, the standard test methods for sampling and testing concrete masonry units and the like. Just like other specimens, sulphur was used as capping to the CHBs tested to attain uniformity in the loading application.

There are five (5) identified quarry sources of the aggregates of the CHB samples, namely: for gravel and sand, Bio (Tagudin, Ilocos Sur), Banaoang (Santa, Ilocos Sur), San Nicolas, (Ilocos Norte), and Laoag-Sarrat (Ilocos Norte). Cabugao (Ilocos Sur) quarry is for sand only. Eight (8) towns from the 1st district of Ilocos Sur were taken, while another eight (8) were chosen from the 2nd district of the province. These towns were chosen being the dominant concrete hollow block producers of the two districts of Ilocos Sur, and to thoroughly represent the quarry sources, the towns of Sinait, Cabugao, San Juan, and Magsingal quarry aggregates from Ilocos Norte, because the quarry source is more accessible to them than going further south. The towns of Tagudin, Sta Cruz, Sta. Lucia, Candon quarry at Bio and Tagudin because they are nearer to the quarry source, too, while the rest of the towns quarry at Banaoang or Cabugao, being nearer to their area. The stratified random sampling method was used. CHB samples were bought at three (3) pieces for each thickness of 4 inches, 5 inches and 6 inches from each of five (5) manufacturers chosen at random in the selected municipalities. The manufacturers in the towns of San Vicente and San Juan did not have 6-inch CHBs ready for sale during the data gathering.

The average of the dimensions was taken as basis in the tabulation presented. The variables were then regressed to come up with a model that would compute a reasonable price for a CHB, given its computed strength and distance between the quarry source from which its materials were taken and place where it was produced. Finally, from the original equation, $Y = a + b1X1 + b2X2 + b3X3$, where: X1, X2 and X3 are the independent variables considered to be responsible for the value of the dependent variable, Y, the specific regression equation would be determined. After which, the suggested model would be applied to each of the samples, this predicted price compared to the existing delivery price, then analyzed as to its validity over the said delivery price. With this analysis, the predicted price would be rationalized.

4. RESULTS AND DISCUSSION

4.1. Physical Characteristics of the CHB Samples

The CHB samples were measured to compare their face dimensions to that specified by the Bureau of Product Standards (BPS), specifically the Philippine Trade Standard Specification for Concrete Hollow Blocks (PTS 661-09:1968, covering non-load bearing blocks, as amended by virtue of Standards Administrative Order # 15-1, series of 1973, still in effect at present, providing a basis for common understanding between the manufacturers and their customers both in the local and foreign markets, by setting a standard dimension of concrete hollow blocks. Under the technical requirements, it is stipulated in this specification that no overall dimensions (length, height and width) shall differ by more than 3mm (1/8 in) from the specified dimensions.

Table 1a. Mean Dimensions of the Non-Load Bearing CHB Samples, by Thickness

Municipality	Dimensions in millimeters								
	4"			5"			6"		
	Width	Height	Length	Width	Height	Length	Width	Height	Length
Tagudin	97.79	176.78	400.30	120.65	178.82	393.45	149.86	180.09	400.05
Sta. Cruz	95.25	180.09	398.27	120.14	174.24	389.89	150.11	176.53	400.05
Sta. Lucia	95.00	178.31	396.75	119.89	173.99	389.38	150.37	177.04	399.54
Candon	96.01	184.40	394.97	125.73	179.83	389.89	146.56	183.39	400.05
Santiago	95.76	184.15	396.24	124.46	180.34	388.62	144.78	184.15	400.81
Sta. Maria	95.76	196.60	397.00	122.68	197.10	401.83	139.95	192.53	394.97
Narvacan	97.54	185.85	400.05	119.89	191.01	400.05	141.22	189.23	398.78
Santa	97.54	183.90	398.53	124.97	175.01	400.05	144.78	190.50	393.70
Sta. Catalina	97.79	184.15	400.30	120.65	173.99	396.24	139.70	189.23	396.24
Bantay	96.77	182.37	397.00	117.86	189.99	400.05	140.97	187.96	398.02
Vigan	97.79	185.93	401.32	123.70	186.69	393.45	139.95	179.83	400.05
San Vicente	95.25	189.23	400.05	118.11	187.96	394.46	-	-	-
Magsingal	93.22	189.48	397.51	119.38	191.77	389.89	138.43	188.72	397.51
San Juan	98.81	195.07	400.05	111.76	180.09	378.21	-	-	-
Cabugao	88.39	169.67	384.30	117.35	169.93	380.75	142.75	183.39	383.29
Sinait	96.01	192.53	387.60	120.65	171.96	379.73	149.86	189.99	400.05
Mean	95.92	178.66	396.89	120.49	181.42	391.62	144.24	185.18	397.36
Specified Nominal Dimension	101.00	203.00	406.00	127.00	203.00	406.00	152.00	203.00	406.00
Variance	5.66	44.59	24.04	11.23	64.11	50.90	14.93	25.83	28.38
Std. Deviation	2.38	6.68	4.90	3.35	8.01	7.13	3.86	5.08	5.32

This part of the specification considers the human error during the cubing/compacting stage. The specified nominal face dimensions, the computed means, actual and allowable percent differences from the nominal dimensions are reflected in Table 1a. When the actual and allowable percent differences were compared, not a single block was found to be meeting the prescribed nominal dimension of the faces as all computed means for the width, height and length are smaller. This indicates that as to size requirements, the CHB manufacturers are short of the standard dimensions prescribed.

Looking at the computed standard deviation per town, the dimensions are varied. Among the 4" thick CHB samples, their widths reflect a standard deviation of 2.38mm. This is the least among the standard deviations of heights and lengths among the samples compared, suggesting the varied dimensions of the samples, especially the heights. Because of the closeness of the standard deviations computed under thickness, then the samples could be described as more or less similar. Nonetheless, the samples are all smaller that the specified nominal dimensions. The standard deviation computed under the heights and lengths are bigger. This suggests that the dimensions on heights and lengths of the samples are more varied. The manufacturers might be using different sizes of molds to explain their variations in the dimensions. Therefore, the molds used, being with various sizes, are not standard. Or, if the molds are standard, there could be manipulations done to the molds to lessen their material content.

A more in-depth physical analysis of the non-load bearing CHB samples was further done by looking at the standard deviation of the samples per town to provide a sound statistical proof of the samples not meeting the standard dimensions prescribed by the PTS 661-09.11:1968, amended in 1973, which are also the expected dimensions for sale in the market. Table 1b shows the computed values.

Table 1b. The Standard Deviation of the Non-Load Bearing CHB Samples, by Dimension, by Town

Town	4"			5"			6"		
	SD_W	SD_H	SD_L	SD_W	SD_H	SD_L	SD_W	SD_H	SD_L
Tagudin	0.34	1.56	2.15	0.79	1.04	1.54	3.44	4.84	1.52
Sta. Cruz	1.84	1.71	0.82	0.28	3.62	3.84	2.11	2.46	1.89
Sta. Lucia	0.50	0.40	0.50	0.92	2.93	1.64	4.59	1.74	8.35
Candon	0.79	0.89	0.30	1.02	0.59	2.82	4.75	5.08	1.94
Santiago	0.62	0.57	0.36	0.78	0.86	1.08	2.28	3.50	2.25
Sta. Maria	0.89	0.18	1.03	0.30	1.10	3.85	1.69	1.50	2.98
Narvacan	0.56	0.61	1.07	1.18	1.20	4.14	0.87	3.19	2.12
Santa	0.96	0.70	1.77	0.71	3.42	3.49	0.31	3.34	1.06
Sta. Catalina	0.35	1.52	0.80	0.92	0.83	4.30	4.45	0.58	2.63
Bantay	0.41	1.39	1.60	0.82	2.40	1.69	1.67	1.88	2.25
Vigan	1.45	1.06	0.55	0.31	2.23	1.54	5.79	3.88	9.01
San Vicente	0.25	1.77	0.37	0.89	1.31	3.44	-	-	-
Magsingal	0.40	0.76	1.11	0.84	2.00	1.77	3.73	3.15	3.49
San Juan	0.47	0.80	1.05	0.69	1.74	10.10	-	-	-
Cabugao	1.32	1.85	1.48	1.35	0.26	3.58	2.41	1.87	2.37
Sinait	0.74	1.48	0.84	0.14	1.58	1.64	3.91	2.14	5.43

Standard deviation describes the variability of samples. Among the 4-inch thick CHBs, their thickness, height and lengths do not vary so much, among the towns, as seen from the close values of their standard deviations. The samples from Sta. Cruz have the most varied thicknesses with 1.84 mm, those from Cabugao have the largest variability in height at 1.85mm, and those from Tagudin have the largest variability in length at 2.15mm. Among the 5-inch thick CHBs, the samples from Cabugao have the most varied thickness at 1.35 mm, those from Sta. Cruz have the most varied at 3.62mm, while those from Sta. Cruz and Sta. Maria have the most varied lengths. Among the 6-inch thick CHB samples, those from Vigan have the most varied thicknesses at 5.79 mm, those from Candon have the most varied heights at 5.08 mm, and those from Vigan reflects the most varied lengths at 9.01 mm. However, in all the three observed dimensions, there were no CHB samples reaching the dimensions of the standard size of 101 mm. x 203 mm. x 406 mm. for the 4-inch thick CHB, 127 mm. x 203 mm. x 406 mm. for the 5-inch thick CHB, and 152 mm. x 203 mm. x 406 mm. for the 6-inch thick CHB. Neither were there samples which the DTI-BPS tolerates at a ±3mm, or 3 millimeters longer or shorter than the standard sizes of CHB as mentioned in Philippine Standard Specifications for Concrete Hollow Blocks.

Table 2. Standard Deviation of Non-Load Bearing CHB Samples by Dimension and by Town

Town	4"			5"			6"		
	SD_W	SD_H	SD_L	SD_W	SD_H	SD_L	SD_W	SD_H	SD_L
Tagudin	0.34	1.56	2.15	0.79	1.04	1.54	3.44	4.84	1.52
Sta. Cruz	1.84	1.71	0.82	0.28	3.62	3.84	2.11	2.46	1.89
Sta. Lucia	0.50	0.40	0.50	0.92	2.93	1.64	4.59	1.74	8.35
Candon	0.79	0.89	0.30	1.02	0.59	2.82	4.75	5.08	1.94
Santiago	0.62	0.57	0.36	0.78	0.86	1.08	2.28	3.50	2.25
Sta. Maria	0.89	0.18	1.03	0.30	1.10	3.85	1.69	1.50	2.98
Narvacan	0.56	0.61	1.07	1.18	1.20	4.14	0.87	3.19	2.12
Santa	0.96	0.70	1.77	0.71	3.42	3.49	0.31	3.34	1.06
Sta. Catalina	0.35	1.52	0.80	0.92	0.83	4.30	4.45	0.58	2.63
Bantay	0.41	1.39	1.60	0.82	2.40	1.69	1.67	1.88	2.25
Vigan	1.45	1.06	0.55	0.31	2.23	1.54	5.79	3.88	9.01
San Vicente	0.25	1.77	0.37	0.89	1.31	3.44	-	-	-
Magsingal	0.40	0.76	1.11	0.84	2.00	1.77	3.73	3.15	3.49
San Juan	0.47	0.80	1.05	0.69	1.74	10.10	-	-	-
Cabugao	1.32	1.85	1.48	1.35	0.26	3.58	2.41	1.87	2.37
Sinait	0.74	1.48	0.84	0.14	1.58	1.64	3.91	2.14	5.43

Table A.1 presents a summary table on the data gathered, which include the aggregate sources, the distances of the quarry sites to the CHB manufacturers' place, the CHB sizes produced, the pick-up and delivery prices, and the strength of each piece as expressed from the test results, discussed in detail in the subsequent paragraphs.

Only five (5) of the sixteen (16) towns considered reflected pick-up prices of non-load bearing concrete hollow blocks manufactured therein (refer to Column 5a). However, the delivery price of concrete hollow blocks is reflected completely by town (refer to Column 5b). This is due to the fact that CHB manufacturers when they sell their products deliver the ordered number of pieces directly to the construction sites by trucks. There are seldom cases of clients buying with vehicles to carry the CHBs purchased.

4.2 Pick-Up and Delivery Prices

When the pick-up prices were analyzed, the computed mean is Php7.75, while the mean of the delivery prices is Php8.87. The delivery prices were further checked if they follow a normal distribution. Their probability distribution is plotted using the computed mean and standard deviation. The resulting graph is a normal curve, bell-shaped, suggesting that the appropriateness of the statistical treatment chosen, the *t*-test for independent data. The *p*-value is 0.784, making it significant. This means that the pick-up prices are consistently lower than the delivery prices, which is just rational. When customers buy hollow blocks and transport the products by their own vehicles, the manufacturers would incur less expenses in terms of fuel and labor. This saving is translated into a discount in the delivery price per product, which is computed to be Php1.13, on the average, as shown in Table 2.

Table 3. Comparison between Pick-up and Delivery Prices of CHBs in Selected Towns With the Pick-up Mode of Selling CHBs

Municipality`	Size	Price, P		Difference in Price (PHP)
		Pick-up	Delivery	
Tagudin	4"x8"x16"	5.00	8.00	3.00
	5"x8"x16"	6.00	9.00	3.00
	6"x8"x16"	7.00	10.00	3.00
Sta. Catalina	4"x8"x16"	8.00	9.00	1.00
	5"x8"x16"	9.50	10.50	1.00
	6"x8"x16"	12.00	13.00	1.00
San Juan	4"x8"x16"	7.00	8.00	1.00
	5"x8"x16"	8.00	9.00	1.00
Cabugao	4"x8"x16"	6.75	7.00	0.25
	5"x8"x16"	7.75	8.00	0.25
	6"x8"x16"	8.50	9.00	0.50
Sinait	4"x8"x16"	6.50	6.70	0.20
	5"x8"x16"	7.70	7.40	-0.30
	6"x8"x16"	8.80	9.70	0.90
Total Difference Between Delivery and Pick-up Prices				15.80
Average Difference Between Delivery and Pick-up Prices				1.13

4.3 Delivery Prices of the CHB Samples

It is a procedure of the analysis of variance to group samples which are more or less the same to further describe group means. The groupings were the CHB samples by size from each town. This was done because the CHBs were produced using different quarry sources. As explained earlier, the manufacturers hauled aggregates according to their proximity to the place of production.

The one-way analysis of variance (ANOVA) of the prices of CHB samples analyzed the differences between the means computed per town and their variation between and among the samples. The *F*-prob is 0.329, while the *F*-ratio is 1.195. Because the *F*-prob < *F*-ratio, there are no significant differences among the delivery prices. This simply means that the prices of the concrete hollow blocks are the same in the towns where the CHB samples were taken. This finding leads to the prevailing fact that the delivery prices of 4-inch thick CHB in Vigan City are not significantly different from the delivery prices in Tagudin, or any other town. Likewise, the same is also true for the delivery prices of 5-inch and 6-inch thick CHBs in all the selected towns.

4.4 Delivery Prices vis-a-vis Distance of the Quarry Source to the Place of Production

To test if there exist significant relationship between the delivery prices and the distance of the source of quarry and the place of production, the Pearson *r* is used, using the data in Columns 4 and 5b in Table A.1.

The computed *r*-value is 0.322, which is not significant at the 0.01 level of significance. This means that there exists no significant relationship between the delivery prices and the distance traversed by the manufacturer in hauling his aggregates from the quarry site to his location of production. This implies that the distance is not a factor to influence the delivery price of the concrete products under study.

A closer study on Table A.1 (please refer to the Appendix) would lead us to these observations which would corroborate to the finding that distance was not considered in the price set by the CHB manufacturers. Tagudin is only 4 km from the quarry site, Bio. The prices for 4”, 5” and 6” CHB are P8.00, P 9.00 and P10.00, respectively. Sta. Cruz is 19 km away, but the CHBs are sold at a cheaper price of P7.00. P8.00 and P9.00, for 4”, 5” and 6”, respectively. Sta. Lucia, which is 23 km away from the quarry site also have the same pricing as those in Sta. Cruz. Candon (35 km away from the quarry site) has slightly higher prices than Sta. Lucia.

Likewise, the CHBs manufactured in Sta. Maria, 25 km away from the Banaoang quarry pit, cost P7.17, P8.27, P9.33 for 4”, 5” and 6” CHB, respectively, while those in Santa (only 8 km from the quarry pit) are sold at P8.00, P9.00 and P10.00, for 4”, 5” and 6” blocks, respectively. In San Juan, Ilocos Sur where the manufacturers haul their aggregates at San Nicolas, Ilocos Norte, about 58 km away, sell CHBs at P8.00, P 9.00 for 4” and 5” thick blocks. Cabugao manufacturers haul aggregates right at their own river banks with only 1.5 km drive, yet, CHBs are sold at P7.00. P8.00 and P9.00 for 4”, 5” and 6” thick blocks, respectively, similar to the pricing of Sta. Cruz with 19 km distance from the quarry site. Obviously, the distance was not considered in setting the delivery price.

4.5. Delivery Prices vis-a-vis Compressive Stresses

Similarly, the Pearson *r* is used to test if there exists a significant relationship between the delivery prices and the compressive strength of the samples, using the data in Columns 5b and 6 in Table A.1.

The computed r-value is 0.388, (p=0.008), which is significant at 0.01 level according to the values and degree of correlation as computed and interpreted by the Statistical Package for Social Sciences software (SPSS) 17.0. This means that strength is a factor in setting the price of the concrete hollow blocks.

The strength, aside from the ultimate compressive stress, fc’, which is determined by subjecting the blocks in the Universal Testing Machine through destructive testing, could be practically assessed by merely considering their firmness when carried or transported. This could be indicated by the proportion being adopted by the manufacturers. The more CHBs made out of one bag of cement, the weaker is the resulting mixture. Interviews with local producers supplied the researchers the information that for the 4” CHB, they target at most 85 pieces could be produced per bag of cement per bag of cement, 75 pieces for 5” CHB, and 65 pieces for 6” thick CHB. The lesser the number produced per bag, the harder and stronger the resulting CHBs become.

4.6 Delivery Price vis-a-vis Thickness of the Concrete Hollow Blocks

Still using the Pearson *r* to test if there exists a significant relationship between the delivery prices and the thickness of the concrete hollow blocks, it was found out that *r* is 0.701 which is highly significant at 0.01 level of significance. Therefore, the thickness is really a factor in determining the price, suggesting that the greater the thickness, the higher is the price. Table A.1 shows the delivery and pick up prices (for a few towns) by thickness of CHB per town. In all the samples, the 6” samples costed higher than the 5” and the 4” samples.

4.7 The Compressive Strengths of the Concrete Hollow Blocks

The one-way analysis of variance (ANOVA) of the compressive strength tests of the CHB samples using Column 6 in Table 1 shows that the *F*-prob is 0.138, while the *F*-ratio is 1.599. Since *F*-prob < *F*-ratio, this means that the compressive strengths are not significantly different between and among the CHB groups. This result suggests that the data analyzed are more or less the same.

Moreover, the mean of CHB samples was computed per thickness, shown in Table 1a, it was found out that the compressive strength of the CHB samples were very low when compared to the minimum specified fc’ set by the DTI-BPS, through the provision of PTS 661-09.11:1968, the minimum compressive strength of individual non-load bearing concrete hollow blocks is 350 psi (2.07 MPa) shown also in Table 4. Numerically describing the difference of the standard size and the manufactured sizes, the 4-inch thick CHB samples are 79.6% deficient in strength from that prescribed standards, while the 5-inch CHB samples are 71.93% deficient, and the 6-inch CHB samples are 60.48% deficient. Again, this finding traces the laxity of the monitoring agency for this commodity under study.

Table 4. The Average Compressive Stresses, fc', of the CHB Samples by Thickness and by Municipality

Municipality	Compressive Strength (MPa)		
	4"	5"	6"
Tagudin	0.57	0.35	0.404
Sta. Cruz	0.59	0.61	0.53
Sta. Lucia	0.49	0.50	0.57
Candon	0.33	0.32	1.39
Santiago	0.35	0.36	-
Sta. Maria	0.44	0.40	2.11
Narvacan	0.38	0.66	0.44
Santa	0.45	0.35	0.63
Sta. Catalina	0.26	0.25	0.37
Bantay	0.58	1.79	0.48
Vigan	0.44	1.87	2.78
San Vicente	0.26	0.25	-
Magsingal	0.48	0.36	0.31
San Juan	0.40	0.61	-
Cabugao	0.39	0.33	0.21
Sinait	0.35	0.29	0.41
Mean	**0.42**	**0.58**	**0.82**
Minimum Specified fc'	**2.07**	**2.07**	**2.07**
% Difference from Recommended Strength	**79.60**	**71.93**	**60.48**

A closer look on Table A.1, particularly in Columns 4 (size), 5b (delivery price) and 6 (strength), shows that, generally, those samples that registered higher compressive stresses, fc', also costed higher. In Sta. Maria, one of the strongest samples, had its fc' at 2.11 MPa and was sold at P9.33 per piece, while a weaker one with an fc' of 0.41 MPa costed only P7.00. The strongest among the samples was traced to have been produced in Vigan, and it costed P13.00, while a weaker one in Sta Catalina, was sold for only P12.00. Because strength could be easily gauged by the hardness during the transport and delivery time, producers are more confident to set higher prices when they are sure of the strength of their products.

4.8 Defining the Delivery Price of Concrete Hollow Blocks Considering the Compressive Strength, Thickness and Distance of Quarry Source to the Location of Production

The linear regression model is used to establish a rational equation to set the delivery price of the concrete hollow blocks, considering the strength of the finished product and the distance travelled to haul aggregates for its production. In general form, the equation would be:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 \qquad (2)$$

where X_1, X_2 and X_3, are the independent variables, a, b_1 and b_2 are coefficients and Y is the dependent variable.

Table 5 presents the values of the constant and coefficients of the independent variables.

Table 5. Regression Analysis of the Delivery Price, Compressive Strength, Thickness, and Distance of Quarry Source to Location of Production

	b	Std. Error	Beta	*t*-value	Remarks
Constant	4.148	1.080		3.84	
Compressive Strength (f_c')	0.711	0.322	.268	2.210**	Significant
Distance (d)	-0.012	0.011	-.132	-1.113	Not Significant
Thickness (t)	0.913	0.213	.517	4.283**	Significant

*Multi-R = .654 F-ratio = 10.224** R^2=.428 F-sig = .000* **t-value is significant at 0.01 prob level

Having identified that the price of concrete hollow blocks is significantly related to its strength, so with the thickness, and that the distance of the source of aggregates to the location of production has no significant effect therein, the values of the regression analysis in Table 5 are now interpreted to propose the delivery price of the CHB products with the following equation:

$$Y = 4.148 + 0.711f_c' + 0.913t \quad (1)$$

where:
Y = the delivery price of the CHB
f_c'= the compressive strength of the CHB produced
t = the thickness of the concrete hollow block

It is also indicated below the table that the independent variables, strength and thickness, taken singly, significantly influence the delivery price, while distance does not. Taken as a whole, the variables could account about 65.4% of the variance in setting up the rational price of the commodity sold. The remaining 34.6% are attributed by other variables not considered in this study.

Since the result of the regression equation in Table 5 still reflects the distance, which is insignificant, the variables were again regressed giving the resulting constants shown in Table 6.

Table 6. Regression Analysis of the Delivery Price, Compressive Strength, Thickness, and Distance of Quarry Source to Location of Production

	b	Std. Error	Beta	t-value	Remarks
Constant	3.836	1.046		3.667**	
Strength (f_c')	0.748	0.321	.282	2.331*	Significant
Thickness (t)	0.920	0.214	.521	4.303**	Significant

*Mult-R = .641 F-ratio = 14.634*** ***t-value significant at 0.01 prob level*
R^2=.411 F-sig = .000 ** t-value significant at 0.05 prob level*

The thickness is the first and foremost factor in setting the price of CHB, as shown by the indicated delivery prices in Table A.1. In Tagudin, the price of a 4-in thick CHB is P8.00, P9.00 for a 5-inch thick block, while P10.00 for a 6-inch block. Almost all the municipalities set a P1.00 difference in the prices of the commodity under study, and it is very clear from the listed prices that the 4-inch thick block costs less than both the 5-inch and 6-inch block, and conversely. The 6-inch thick block has always the highest price among the three common thicknesses sold in the market.

The strength factor, fc', influences the price of CHB in a way that is implied, since this property of the product is not directly known unless the block is subjected to destructive testing. Strength is integrated in the mixture or proportioning of cement, sand and choke. The more blocks produced, the weaker they become because of the decreasing proportion of cement with the aggregates. Cement is the binder of the aggregates. The more cement binds them, the stronger is the mixture, and the more cement is used, the more is the cost incurred, thus rationalizing the higher price.

Distance did not influence the price because the manufacturers set their price regardless of their distance from the quarry site. As already, mentioned in Section 4.3, the unit prices have no significant differences. The delivery price of a 4 inch-thick CHB in Tagudin is P8.00, with aggregates hauled from Bio, Tagudin, just 4 km away. A 4-inch thick CHB in Candon costs P8.67, with aggregates hauled at Bio, Tagudin also, 35 km away. A 4-inch thick CHB in Sta. Maria costs P7.17 with aggregates hauled from Banaoang, Santa, 25 km. away, while a 4-inch thick CHB at Narvacan, 19 km. away from the quarry source, costs only P7.00. Evidently, the distance was not considered in setting the price of the commodity under study.

Using the proposed regression model, the suggested prices of the concrete hollow blocks are shown in Column (f) in Table 6. Column (g) rounds off the predicted price to set the selling price. Column (e) shows the delivery price of the CHBs for an easier comparison with the predicted price. Generally, the predicted prices do not go far from the delivery prices. The delivery prices for 4-inch, 5-inch and 6-inch thick samples are exactly the same with the predicted prices of Tagudin, Santa and San Juan, while the rest are about a peso higher or lower than the delivery prices. This suggests that the delivery prices in these towns fit into the model regression equation. The predicted prices of the CHB samples in Sta. Cruz, Sta. Lucia, Narvacan, Sta. Maria, Magsingal, Cabugao and Sinait, are higher than the delivery prices by one peso. This means that the delivery prices in these towns were set lower, without due consideration of the thickness and strength factors of the samples. The manufacturers or dealers may prefer a cheaper pricing of these construction items to invite more buyers. On the other hand, delivery prices of the samples in Candon, Sta. Catalina and Vigan were higher than the predicted price, probably due to commercialized production, not considering the strength of the products sold but just to realize more profit. Other towns have their delivery prices either lower or higher with the thickness of the construction item presently scrutinized.

Table 7. Application of the Regression Model on the Delivery Prices of Non-Load Bearing Concrete Hollow Blocks

Municipality (a)	Size (c)	Compressive Strength, MPa (d)	Delivery Price (P) (e)	Theoretical values of Predicted Price (P)(f)	Proposed Selling Price rounded from the model (P) (g)
Tagudin	4"x8"x16"	0.57	8.00	8.21	8.00
	5"x8"x16"	0.35	9.00	8.96	9.00
	6"x8"x16"	0.40	10.00	9.91	10.00
Sta. Cruz	4"x8"x16"	0.59	7.00	8.22	8.00
	5"x8"x16"	0.61	8.00	9.15	9.00
	6"x8"x16"	0.53	9.00	10.00	10.00
Sta. Lucia	4"x8"x16"	0.49	7.00	8.15	8.00
	5"x8"x16"	0.5	8.00	9.07	9.00
	6"x8"x16"	0.57	9.00	10.03	10.00
Candon	4"x8"x16"	0.33	8.67	8.03	8.00
	5"x8"x16"	0.32	9.83	8.94	9.00
	6"x8"x16"	1.39	10.83	10.61	11.00
Santiago	4"x8"x16"	0.35	8.00	8.05	8.00
	5"x8"x16"	0.36	10.00	8.97	9.00
Sta. Maria	4"x8"x16"	0.44	7.17	8.11	8.00
	5"x8"x16"	0.40	8.27	9.00	9.00
	6"x8"x16"	2.11	9.33	11.13	11.00
Narvacan	4"x8"x16"	0.38	7.00	8.07	8.00
	5"x8"x16"	0.66	8.00	9.18	9.00
	6"x8"x16"	0.44	9.00	9.94	10.00
Santa	4"x8"x16"	0.45	8.00	8.12	8.00
	5"x8"x16"	0.35	9.00	8.96	9.00
	6"x8"x16"	0.63	10.00	10.07	10.00
Sta. Catalina	4"x8"x16"	0.26	9.00	7.80	8.00
	5"x8"x16"	0.25	10.50	8.89	9.00
	6"x8"x16"	0.37	13.00	9.89	10.00
Bantay	4"x8"x16"	0.58	8.33	8.21	8.00
	5"x8"x16"	1.79	9.33	9.99	10.00
	6"x8"x16"	0.48	11.50	9.97	10.00

Table 7. Application of the Regression Model on the Delivery Prices of Non-Load Bearing Concrete Hollow Blocks (continued)

Municipality (a)	Size (c)	Compressive Strength, MPa (d)	Delivery Price (P) (e)	Theoretical values of Predicted Price (P)(f)	Proposed Selling Price rounded from the model (P) (g)
Vigan	4"x8"x16"	0.44	8.25	8.11	8.00
	5"x8"x16"	1.87	9.25	10.04	10.00
	6"x8"x16"	2.78	13.00	11.60	ko.00
San Vicente	4"x8"x16"	0.26	8.00	7.98	8.00
	5"x8"x16"	0.25	9.50	8.89	9.00
Magsingal	4"x8"x16"	0.48	7.00	8.14	8.00
	5"x8"x16"	0.36	8.00	8.97	9.00
	6"x8"x16"	0.31	9.00	9.85	10.00
San Juan	4"x8"x16"	0.4	8.00	8.08	8.00
	5"x8"x16"	0.607	9.00	9.14	9.00
Cabugao	4"x8"x16"	0.39	7.00	8.08	8.00
	5"x8"x16"	0.33	8.00	8.95	9.00
	6"x8"x16"	0.21	9.00	9.78	10.00
Sinait	4"x8"x16"	0.35	6.70	8.05	8.00
	5"x8"x16"	0.29	7.40	8.92	9.00
	6"x8"x16"	0.41	9.70	9.92	10.00

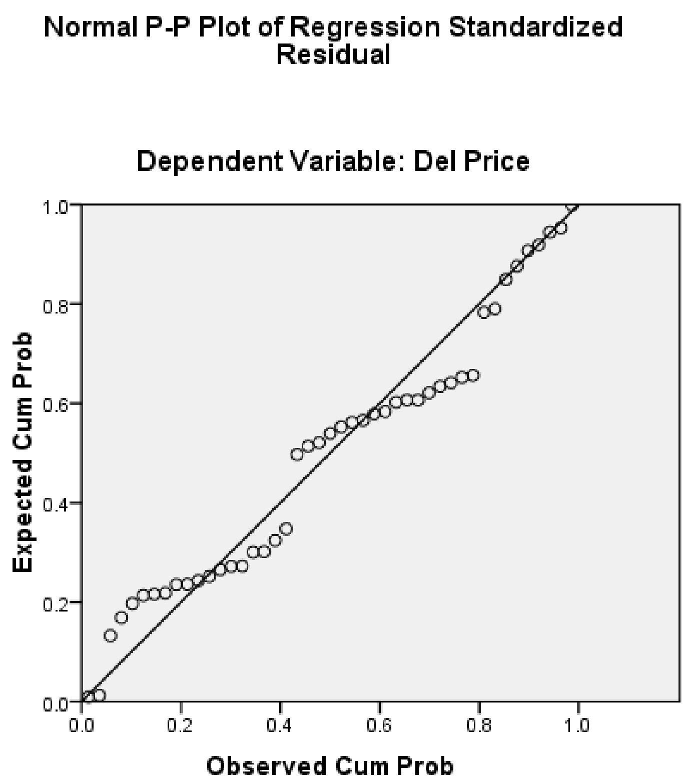

Figure 1. The Regression Line

4.9 The Regression Line Showing the Residuals

A clearer analysis of the samples could also be provided by the regression line shown in Figure 1. The bold line shows the predicted value of the price, Y, the dependent variable, for any value of the independent variables, which are thickness and strength of the samples. The residuals represent those samples which do not fit in the regression line, also shown in Figure 1. They are those samples who had weak proportions of cement-sand-gravel and water but were sold in equal value like the stronger ones. Such residuals are identified specifically by looking closer to Table A.1. It was pointed out in Sections 4.6 and 4.7 the influence of strength and thickness to the delivery price, as set arbitrarily by the producers per town, then in the proposed model generated from the regression equation. The thickness is undoubtedly the price setter, but not for strength. For example, if a strong 6" sample at 2.11 MPa is sold at Php9.33, there is a weak 6" sample at 0.61 MPa being sold at Php9.00. The price is quite close to the previous sample, which is a lot stronger. Again, a 0.21 MPa- 6" sample costs Php9.00. Another is a 0.31 MPa 6" sample sold at Php9.00. These do not follow the rational pricing by the model.

5. CONCLUSIONS

In light of the above findings, the following conclusions are now drawn:

1. The non-load bearing concrete hollow blocks taken as samples are smaller than the recommended standard sizes set by the Philippine Trade Standards
2. Majority of the CHB manufacturers sell their products through delivery.
3. The savings generated by the non-load bearing CHB manufacturers are translated into P1.13 average discounts of the delivery price when sold at the production sites.
4. CHB manufacturers set their delivery prices uniformly, aiming to sell their products competitively with fellow manufacturers from adjacent towns regardless of the distance they travel in quarrying their materials for production.
5. The strength of a non-load bearing hollow block is a significant parameter in setting up its price.
6. The strength of the CHB produced and distance of the source of materials for production and thickness of the CHB do not sufficiently explain the rational pricing of CHB products, as shown by the final R value of 65.4%. The 34.6% are accounted by other factors not captured by this study.

6. RECOMMENDATIONS

Picking up from the unaddressed issues of the study, the following recommendations are forwarded:

1. The distance of quarry site from where the materials to produce non-load bearing concrete hollow blocks are taken should be translated into additional cost in terms of fuel, labor and equipment expenses and other operating expenses incidental thereto. Added cost to the production will significantly affect the price.
2. Standardizing CHB sizes, as well as the number of pieces per bag of cement, considering a minimum specified compressive strength to be attained per manufacturer, will improve the quality of the CHBs produced.
3. Some factors which account 34.6% of the variance for a rational pricing of CHB products should be further identified.

4. Some factors which account 34.6% of the variance for a rational pricing of CHB products should be identified, in which the proposed linear regression equation will become:

Y = a + b1X1+ b2X2+b3X3+ b4X4…+ bn-1Xn-1 + bnXn

X3, X4, Xn-1, Xn, are the other factors to be identified

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9. APPENDIX

Table A.1. Summary Table of the Data Gathered by Municipality

Municipality (1)	Source of Aggregates (2)	Ave Distance from Quarry to Place of Production, km (3)	Size (4)	Price, Ph P		Strength, MPa (6)
				Pick-up (5a)	Delivery (5b)	
Tagudin	Bio, Tagudin	4	4"x8"x16"	5.00	8.00	0.57
			5"x8"x16"	6.00	9.00	0.35
			6"x8"x16"	7.00	10.00	0.40
Sta. Cruz	Bio, Tagudin	19	4"x8"x16"		7.00	0.59
			5"x8"x16"		8.00	0.61
			6"x8"x16"		9.00	0.53
Sta. Lucia	Bio, Tagudin	23	4"x8"x16"		7.00	0.49
			5"x8"x16"		8.00	0.50
			6"x8"x16"		9.00	0.57
Candon	Bio, Tagudin	35	4"x8"x16"		8.67	0.33
			5"x8"x16"		9.83	0.32
			6"x8"x16"		10.83	1.39
Santiago	Bio, Tagudin	44	4"x8"x16"		8.00	0.35
			5"x8"x16"		10.00	0.36
Sta. Maria	Banaoang, Santa	25	4"x8"x16"		7.17	0.44
			5"x8"x16"		8.27	0.40
			6"x8"x16"		9.33	2.11

Table A.1. Summary Table of the Data Gathered by Municipality *(Cont'd)*

Municipality (1)	Source of Aggregates (2)	Ave Distance from Quarry to Place of Production, km (3)	Size (4)	Price, Ph P		Strength, MPa (6)
				Pick-up (5a)	Delivery (5b)	
Vigan	Banaoang, Santa	13	4"x8"x16"		8.25	0.44
			5"x8"x16"		9.25	1.87
			6"x8"x16"		13.00	2.78
San Vicente	Banaoang, Santa	15	4"x8"x16"		8.00	0.26
			5"x8"x16"		9.50	0.25
Magsingal	Banaoang, Santa	26	4"x8"x16"		7.00	0.48
			5"x8"x16"		8.00	0.36
			6"x8"x16"		9.00	0.31
San Juan	San Nicolas, I. Norte	58	4"x8"x16"	7.00	8.00	0.40
			5"x8"x16"	8.00	9.00	0.61
Cabugao	Cabugao River	1.5	4"x8"x16"	6.75	7.00	0.39
			5"x8"x16"	7.75	8.00	0.33
			6"x8"x16"	8.50	9.00	0.21
Sinait	Laoag, Sarrat	46	4"x8"x16"	6.50	6.70	0.35
			5"x8"x16"	7.70	7.40	0.29
			6"x8"x16"	8.80	9.70	0.41
Narvacan	Banaoang, Santa	19	4"x8"x16"		7.50	0.38
			5"x8"x16"		8.50	0.66
			6"x8"x16"		10.50	0.44
Santa	Banaoang, Santa	8	4"x8"x16"		8.00	0.45
			5"x8"x16"		9.00	0.35
			6"x8"x16"		10.00	0.63
Sta. Catalina	Banaoang, Santa	15	4"x8"x16"	8.00	9.00	0.26
			5"x8"x16"	9.50	10.50	0.25
			6"x8"x16"	12.00	13.00	0.37