COST ADVICE ON THE CONSTRUCTION OF SINGLE BRICK WALLS USING BURNT CLAY BRICKS

by

W.V.K.M. Abeysekera

Introduction

An examination of a wall constructed probably about 50 years ago revealed that bricks of size 9"x4"x2½" were used in the construction of walls. A similar examination of a brick wall being demolished for some renovation work revealed that bricks of size 8"x4"x2½" were in use 15 years ago. Today, bricks with dimensions 7.55"x3.58"x1.96" are found to be in use. In contrast, bricks with dimensions of 8.4"x4.1"x2.44" are also being used in the Construction Industry.

On the thickness of mortar joints, the section on "Brick Work & Block Work" in the Sri Lanka Specification for Building Works (Volume I) states thus: "The thickness of mortar joints shall not exceed 10mm". However, the survey undertaken in connection with this study showed that in reality the joint thickness in most brickwalls exceeded the limit specified.

What does all this mean? Is it only common to areas in and around Colombo or is it common to other areas as well? What is the effect of the different brick sizes on cost? Is there a case for the manufacture of non-standard bricks? How does the thickness of joints in brick walls affect the final cost. Does the strength of the wall decrease as a result of thicker joints? If so, to what extent? Will the size of the brick get reduced further in time to come? What about the quality of bricks available today? These are some questions that need to be answered. However, the main object of the paper is to provide answers to some of these questions especially those connected with COSTS.

The following topics are discussed in detail:

Spectrum of brick sizes in and around Colombo.
Spectrum of brick sizes in other areas.
Range of bed mortar and vertical joint thickness.
Cost Saving by the use of large/standard size bricks.
Cost Savings through efficient methods of construction.
Cost Savings by reducing wall/column thickness.
The effect of reducing joint thickness on cost of construction.
Cost Savings of purchasing construction materials in advance.
Cost Savings through the use of diferent mortars.
Cost Savings through the use of common clay bricks as a facing brick.
Cost Savings through market surveys.

Mr. W.V.K.M. Abeysekera, BSc(Eng)Hons, MSc in Construction Management (Loughborough), CEng, MIE(Sri Lanka) graduated with a First Class from University of Sri Lanka, Moratuwa in 1978.

He started his career as an Assistant Lecturer at the University of Moratuwa and worked as a Designs Engineer at the State Engineering Corporation. After working for construction company in Nigeria he joined the State Development & Construction Corporation as the Engineer Planning. At present, he is the Deputy Director (Technology Development) at the Institute for Construction Training & Development.

Recently he was awarded the C.D.E. Award for the best Paper published in the 'Engineer' Journal in the 1985/86 Session.

Spectrum of Brick Sizes in and Around Colombo

In order to establish the brick sizes used in and around Colombo, 41 Sites and 40 Kilns were surveyed. The number of kilns surveyed in different locations are given below.

TABLE I			
Kochchikade	02	Hanwella	11
Waikkal	02	Kaduwella	12
Dankotuwa	01	Galapatha	06
Diruldeniya	03	Bombuwala	02
Kotandeniya	01		

The dimensions of bricks available at a site or at a kiln were established by placing 10 bricks drawn at random, side by side and the dimensions so obtained.

The length to breadth ratios of bricks surveyed were also calculated and found to be in the ranges shown below:

TABLE 2				
Length to Breadth Ratio (L/B)				
	Min	Max	Average	Std.Dev.
Site Survey	1.889	2.198	2.047	0.056
Kiln Survey	1.911	2.137	2.023	0.052

Therefore, it can be seen that for the purpose of study, the average value of length to breadth can be considered to be fixed at 2.047. Even from a practical consideration, i.e. to facilitate stacking this ratio could be considered to be around 2. Hence, the variability of brick sizes can be plotted with respect to length or breadth and height. The results of the Site Survey and Kiln Survey so plotted could be seen in Figure 1 and 2 respectively, with the variables as length and height.

The Table 3 shows the relative proportion of brick dimensions falling within different ranges of brick sizes.

TABLE 3

	Length	Falling within	Height	Falling within
Site Survey	7.6" - 7.7"	26.8%	2.0" - 2.05"	17.1%
	7.7" - 7.8"	17.1%	2.05" - 2.10"	22.0%
	7.8" - 7.9"	19.5%		
	7.6" - 7.8"	43.7%	2.10" - 2.15"	19.5%
	7.6" - 7.9"	63.4%	2.0" - 2.15"	58.34%
Kiln Survey	7.8" - 7.9"	30%	2.0" - 2.05"	17.5%
	7.9" - 8.0"	17.5%	2.05" - 2.10"	25.0%
	8.0" - 8.1"	12.5%		
	7.8" - 8.0"	47.5%	2.10" - 2.15"	5.0%
	7.8" - 8.1"	60.0%	2.0" - 2.15"	47.5%

The differences in results of the Site Survey and Kiln Survey shown in the above Table could be attributed to the fact that the number of kilns surveyed in a certain region is more than another region. The results of the Site Survey could be considered to be more realistic as the volume of brick supplied by the kilns vary considerably.

It is interesting to note the standards laid down by the Sri Lanka Standards Institution with respect to dimensions of bricks from time to time.

CS 39 : 1968 8.7"(220) x 4.1"(105) x 2.6"(65)

SLS 39 : 1978 7.5"(190) x 3.5"(90) x 2.6"(65)

SLS 39 : 1978 8.7"(220) x 4.1"(105) x 2.6"(65)

(Amended in 1981)

The above scenario depicts clearly a problem the Standard Institution had to face during the last decade or so in trying to implement this Standard.

Should all bricks satisfy the dimensional requirement? Does the need for a non-standard brick exist? It is the author's view that a smaller size (conforming to a different standard) would be of use specially because the thickness of a two brick wall could be reduced.

Spectrum of Brick Sizes in other Areas

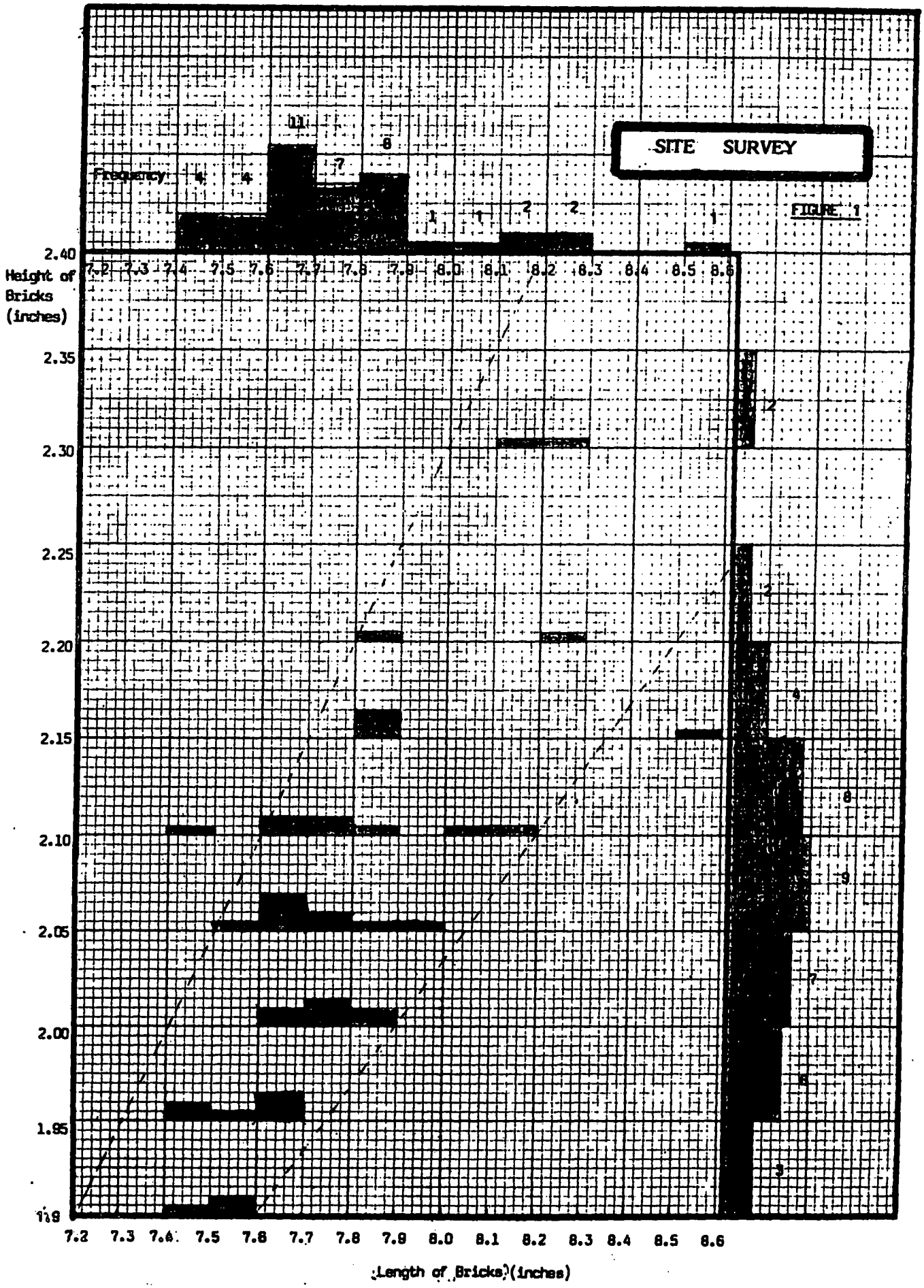
A recent study indicated the following average sizes with respect to the areas given in Table 4.

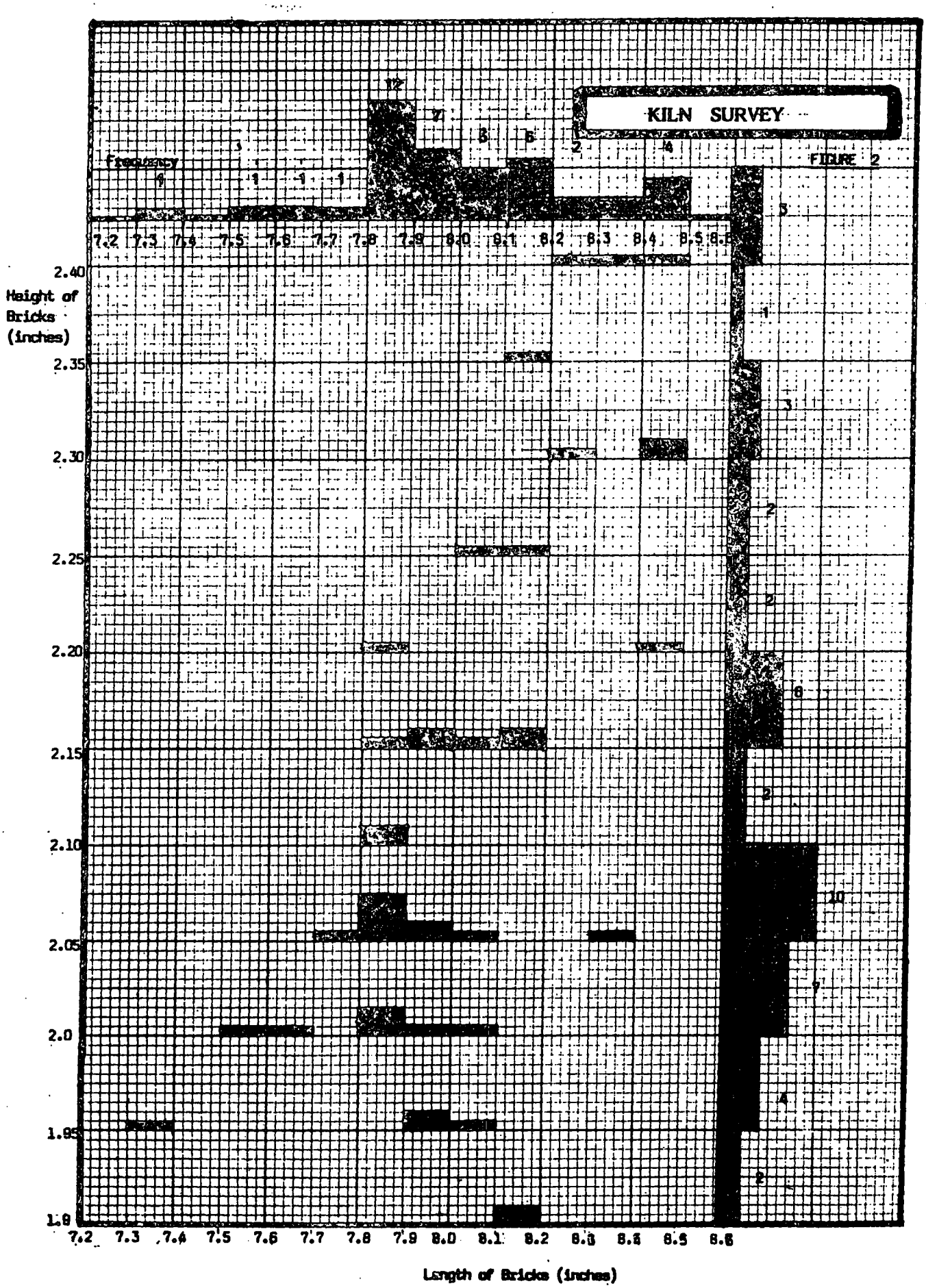
The results shown hitherto show clearly that at present, there aren't any areas which make bricks conforming to dimensions specified in SLSI Standard for bricks. The following observations can be made from the Table 4.

a) In areas such as Kandy, Kurunegala, Polonnaruwa and Ratnapura the average length of bricks exceeds the standard;
b) Among the areas mentioned above, bricks found in Kandy and Ratnapura exceed the width specified in the standard. Further more, the widths of bricks made in the Kalutara area also exceed the width specified.

TABLE 4

Brick Making Area	Average Dimensions	
	Mille - Meters	Inches
1. Hanwella	197 x 97 x 52	7.76x3.82x2.05
2. Malwana	201 x 96 x 55	7.91x3.78x2.17
3. Dankotuwa Kochchikade	198 x 96 x 49	7.80x3.78x1.93
4. kandy	224 x 106 x 51	8.82x4.17x2.01
5. Kurunegala	227 x 102 x 58	8.94x4.02x2.28
6. Deduru Oya	205 x 96 x 53	8.07x3.78x2.09
7. Polonnaruwa	223 x 98 x 57	8.78x3.86x2.24
8. Galle	200 x 99 x 52	7.87x3.90x2.05
9. Hikkaduwa	219 x 101 x 49	8.62x3.98x1.93
10. Kalutara	211 x 108 x 56	8.31x4.25x2.20
11. Ratnapura	223 x 109 x 54	8.78x4.29x2.13


SITE SURVEY
FIGURE 1
Frequency
4
4
11
8
7
1
1
2
2
1
2
2
4
8
9
7
6
3
2.40
2.35
2.30
2.25
2.20
2.15
2.10
2.05
2.00
1.95
1.9
Height of Bricks (inches)
7.2 7.3 7.4 7.5 7.6 7.7 7.8 7.9 8.0 8.1 8.2 8.3 8.4 8.5 8.6
Length of Bricks (inches)


KILN SURVEY
FIGURE 2
Frequency
Height of Bricks (inches)
2.40
2.35
2.30
2.25
2.20
2.15
2.10
2.05
2.0
1.95
1.9
7.2 7.3 7.4 7.5 7.6 7.7 7.8 7.9 8.0 8.1 8.2 8.3 8.4 8.5 8.6
Length of Bricks (inches)

c) The height of the bricks is not found to exceed the limit specified.

It is also seen that smaller bricks are being used not only in and around Colombo but also in other areas as well.

If one is to take advantage of this or make use of these smaller bricks cost effectively, then the advice given in Section (Cost Savings by Reducing Wall/Column Thickness) would bring significant cost savings.

Range of Bed Mortar & Joint Thicknesses

It was stated earlier that "Specifications for Building Works" require the mortar joints to be less than 10 mm. However, in order to establish the mortar joints thicknesses used in practice, a survey was undertaken. In all 17 building sites were visited and from every site, 10 dimensions of Bt, St & Ht were taken from 10 different places. The plots so obtained are shown in Figure 3.

The average joint thickness calculated from the data obtained, are given below:

Bed Mortar Joint Thickness (Bt) = 0.844"

Strecher Course Joint Thickness (St) = 0.9"

Header Course Joint Thickness (Ht) = 0.88"

Therefore, it should be clear by now that, in the preparation of norms, calculation of costs, etc. the various thicknesses to be used should conform to those given above unless of course a 'gauge staff' is used to ensure that, at least, bed mortar joint thickness are maintained to the value specified in the specifications.

The effects of the mortar thickness on the cost of construction are discussed in the next section.

Cost Savings by the Use of Large/Standard Size Bricks for 9" Walls

Price Range of Bricks from Site & Kiln Survey

In order to study the effect of different brick sizes on the overall cost of construction, the prices of bricks obtained during the survey was analysed as shown in Figure 4. The purpose for which each axis was used is stated below:

Left hand side vertical axis = Height of brick

Right hand side vertical axis = Price of 1000 bricks. Each small square represents a price range of Rs.50/-.

Horizontal axis = Length of brick

For the purpose of this study average value of brick prices was adopted with an average height of brick as shown in the top most cage of Figure 5.

Price range of Bricks from Paper Advertisement Calling for the Supply of Standard Size Bricks Conforming to SLSI

For some time now, various discussions, seminars, workshops, etc. have been held to find out ways and means of pursuing the kilns to produce a brick conforming to SLSI Standards. Nevertheless, the situation today is much the same. However, these efforts have not been in vain.

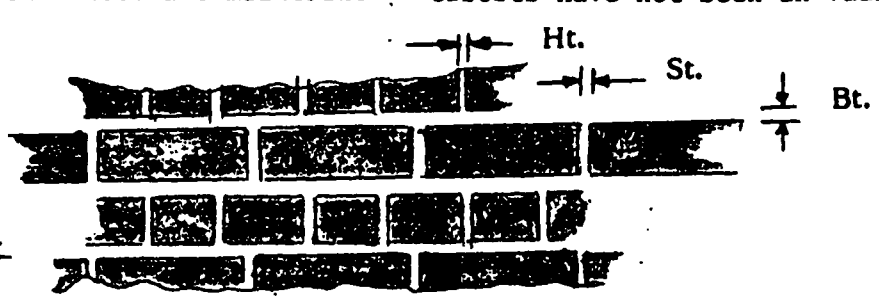
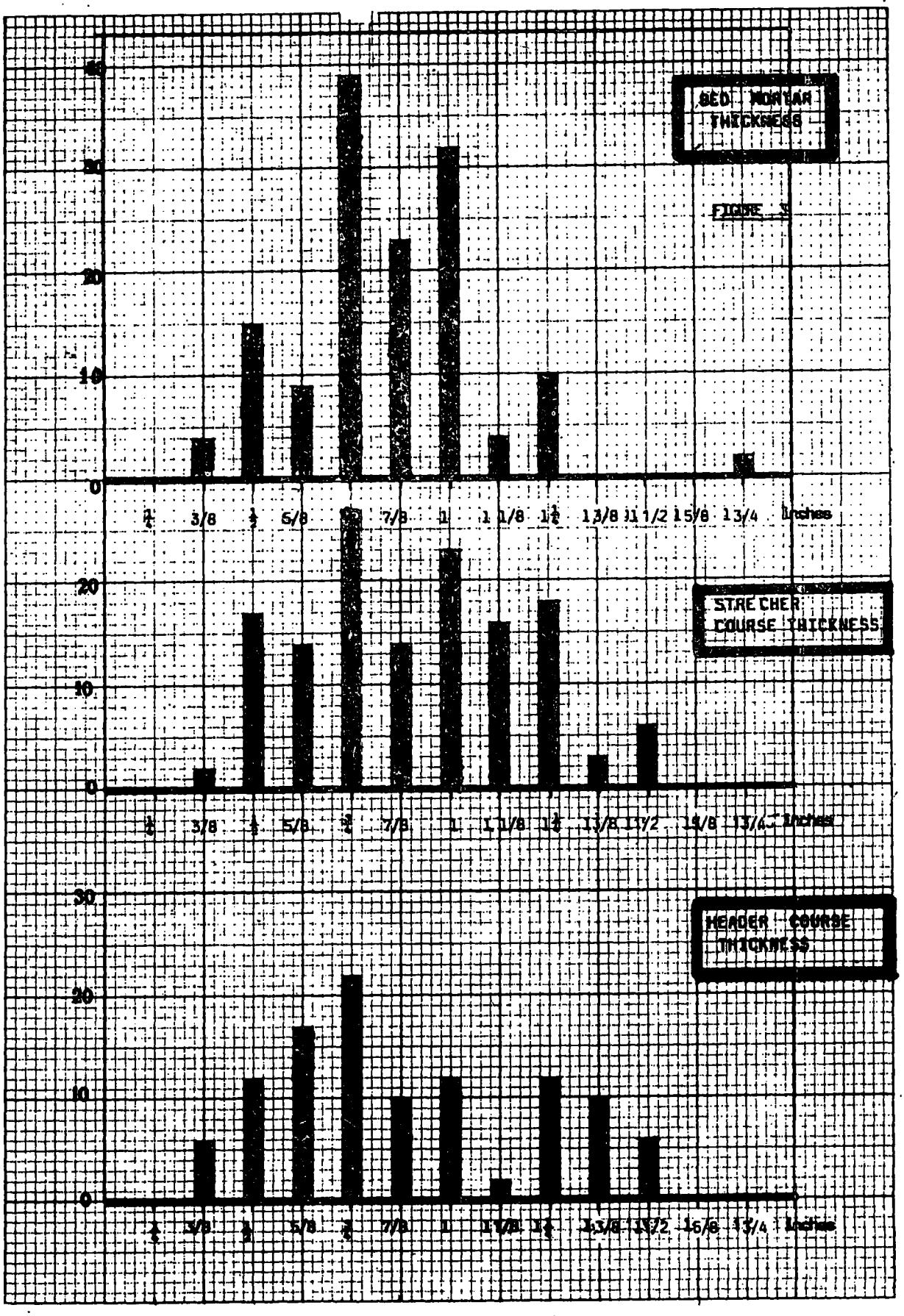
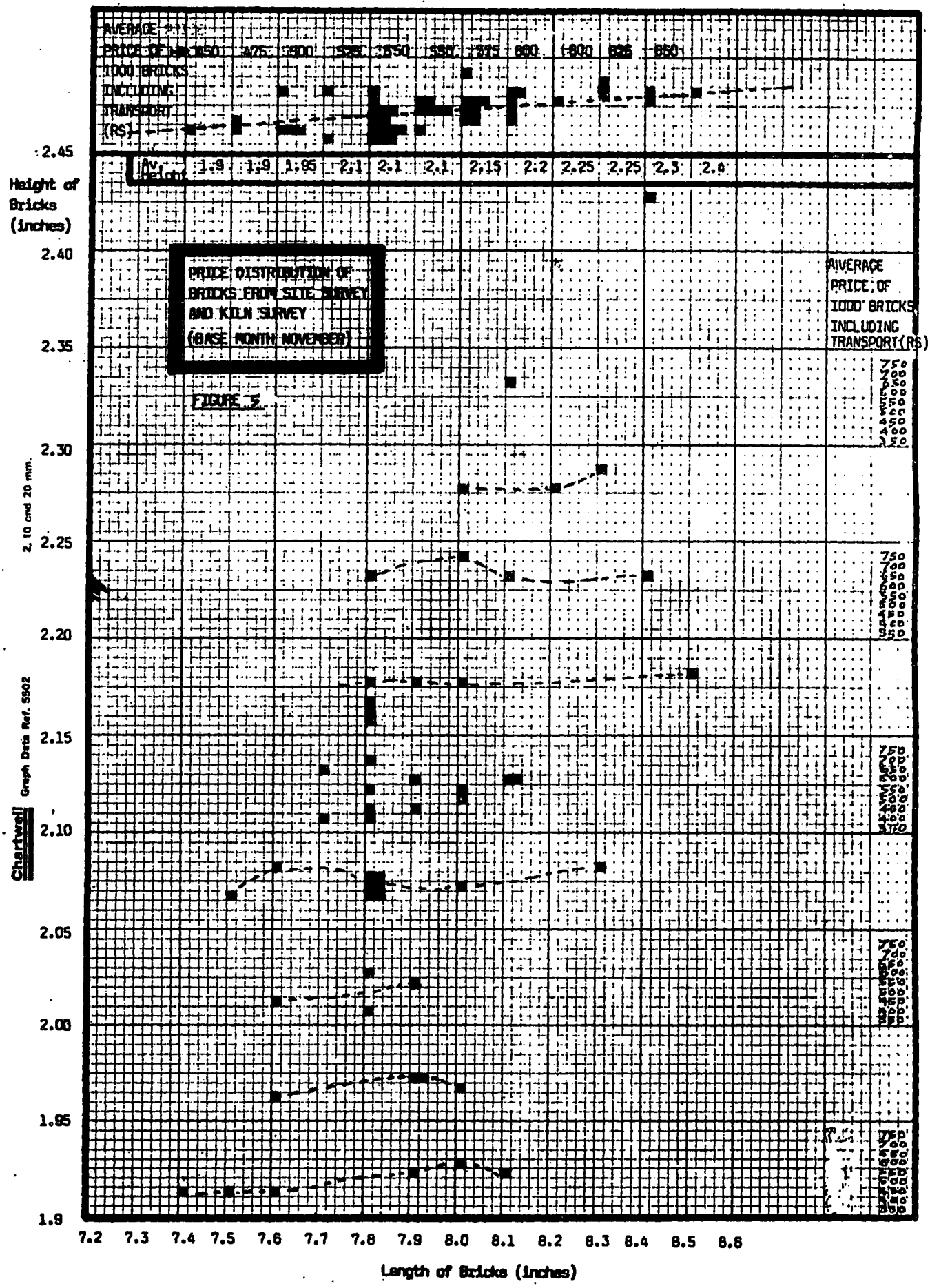


Fig. 4



Chartwell Graph Data Ref. 5502

2, 10 and 20 mm.


AVERAGE PRICE OF 1000 BRICKS INCLUDING TRANSPORT (RS)
Av. Height
PRICE DISTRIBUTION OF BRICKS FROM SITE SURVEY AND KILN SURVEY (BASE MONTH NOVEMBER)
FIGURE 5
AVERAGE PRICE OF 1000 BRICKS INCLUDING TRANSPORT(RS)
Height of Bricks (inches)
2.10 cmd 20 mm.
Chartwell Graph Data Ref. 5802
Length of Bricks (inches)

In the process of visiting kilns to obtain price data and sizes, etc. they were asked whether there were any difficulties in producing a brick at least conforming to dimensions specified in the Standard. The answer to this was negative and nearly all stated that they are prepared to manufacture provided a higher price is paid.

In order to find out the prices required for the supply of standard bricks conforming to SLSI Standard, a Tender Notice was published in the newspaper.

Figure 6 shows the analysis of the tender prices obtained from this advertisement. The wide variation in prices so obtained suggests that some bidders can be considered as 'false bidders'. If only the middle third bids are considered most frequently occuring price range is Rs.625/- to 650/-. If however, the average and the standard deviation of the middle third distribution is calculated it is found to be 604 & 42 respectively. In the analysis to follow the price for 1000 bricks delivered to Colombo was considered to be Rs.650/- (i.e. the Price of Standard bricks conforming to SLSI)

The Effect of Different Brick Sizes on the Cost of Construction

Cost of Construction

In order to calculate the total cost of construction, it is necessary to calculate the following:

a) Number of bricks per cube and the corresponding cost;
b) Cost of labour; and
c) Cost of mortar

The following sections show the various steps involved and the assumptions made in the calculation of a cost one cube of brick work.

Number of Bricks per Cube & Cost of Brick per Cube

Consider a 10 sq.m. wall of size 4m x 2.5m. It was found earlier that,

Bt = 0.844" = 21.4mm;
Ht = 0.88" = 22.3mm and
St = 0.9" = 22.9mm

In order to show the method of calculation consider a sample brick size of 7.3"(185mm) x 3.56"(90.3mm) x 2.00"(50.8mm)

(Note: L/B = 2.047 - derived)

Total number of brick courses = $\frac{2500}{50.8 + 21.4}$ = 34.6

Hence,
No. of strecher courses = 17.6
No. of header courses = 17
No. of bricks per strecher course = (4000 x 2)/(185 + 22.9) = 38.48
No. of bricks per header course = $\frac{4000}{90.3 + 22.3}$ = 35.52

Hence,
No. of bricks per 10 sq.m. area = 17.6 x 38.48 + 17 x 35.52 = 1281

Hence,
No. of bricks per cube = $\frac{1281 \times 0.3048^2 \times 100}{10 \quad 0.75}$ = 1586

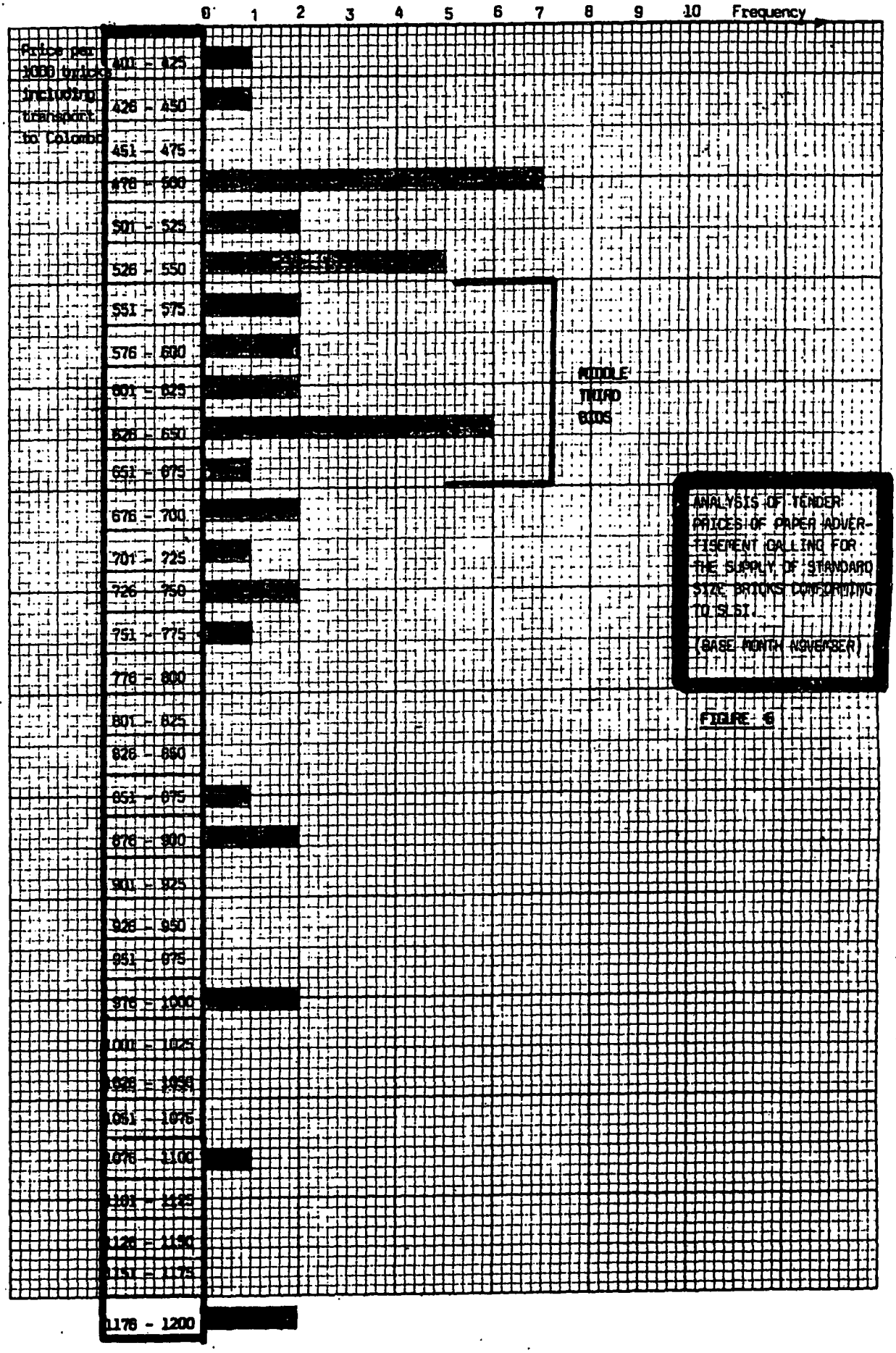
Hence,
No. of bricks per cube with 5% as wastage = 1665

The price for 1000 bricks = Rs.450 (see Fig. 4)
Hence the cost of bricks per cube = 450 x 1.665 = Rs.749.25

Please note that Tables 5 & 6 give the no. of bricks per cube and 10 sq. meters respectively. The calculations undertaken was similar to that shown above.

Cost of labour per Cube

The norm given in the Building Schedule of



ANALYSIS OF TENDER PRICES OF PAPER ADVERTISEMENT CALLING FOR THE SUPPLY OF STANDARD SIZE BRICKS CONFORMING TO SLS1.

(BASE MONTH NOVEMBER)

FIGURE 6

Chartwell Graph Data Ref. 5502 2, 10 and 20 mm.

TABLE 5	NUMBER OF BRICKS PER CUBE OF 9" THICK BRICK MASONRY													
Height (inch) \ Length (inch)	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6
1.9	1643	1624	1606	1588	1570	1553	1536	1520	1503	1488	1472	1457	1442	1428
1.95	1615	1596	1578	1560	1543	1526	1510	1493	1478	1462	1447	1432	1417	1403
2.0	1586	1568	1550	1533	1516	1499	1483	1467	1451	1436	1421	1407	1392	1378
2.05	1558	1540	1522	1505	1489	1472	1456	1441	1425	1410	1396	1381	1367	1354
2.10	1532	1515	1497	1481	1464	1448	1432	1417	1402	1387	1373	1359	1345	1331
2.15	1507	1490	1473	1457	1440	1425	1409	1394	1379	1365	1350	1336	1323	1309
2.20	1482	1465	1448	1432	1416	1400	1385	1370	1356	1341	1327	1314	1300	1287
2.25	1457	1440	1424	1408	1393	1377	1362	1348	1333	1319	1306	1292	1279	1266
2.30	1435	1418	1402	1387	1371	1356	1341	1327	1313	1299	1286	1272	1259	1247
2.35	1413	1397	1381	1365	1350	1335	1321	1307	1293	1279	1266	1253	1240	1227
2.40	1390	1374	1359	1343	1328	1314	1300	1286	1272	1259	1246	1233	1220	1208
2.45	1369	1353	1337	1322	1308	1293	1279	1266	1252	1239	1226	1214	1201	1189
2.50	1349	1333	1318	1303	1289	1275	1261	1247	1234	1221	1208	1196	1184	1172
2.55	1330	1315	1300	1285	1271	1257	1243	1230	1217	1204	1191	1179	1167	1155
2.60	1310	1295	1280	1266	1252	1238	1224	1211	1198	1186	1173	1161	1150	1138

NOTE : The numerical information shown above does not include an allowance for wastage.

The figures within this boundary refers to brick sizes falling within the dotted lines shown in Fig. 1.

Bed thickness = 0.84"

Header thickness = 0.88"

Strecher thickness = 0.90"

TABLE 6	NUMBER OF BRICKS PER 10 SQM OF 225 THICK BRICK WALL													
Length (inch) \ Length (inch)	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6
1.9	1326	1311	1296	1282	1267	1253	1240	1227	1214	1201	1188	1176	1164	1152
1.95	1303	1288	1274	1260	1246	1232	1219	1205	1193	1180	1168	1156	1144	1132
2.0	1281	1266	1251	1237	1224	1210	1197	1184	1172	1159	1147	1135	1124	1112
2.05	1257	1243	1229	1215	1202	1188	1176	1163	1151	1138	1127	1115	1104	1093
2.10	1237	1223	1209	1195	1182	1169	1156	1144	1132	1120	1108	1097	1085	1074
2.15	1217	1203	1189	1176	1163	1150	1137	1125	1113	1101	1090	1079	1068	1057
2.20	1196	1182	1169	1156	1143	1130	1118	1106	1094	1083	1071	1060	1050	1039
2.25	1176	1163	1150	1137	1124	1112	1100	1088	1076	1065	1054	1043	1032	1022
2.30	1158	1145	1132	1119	1107	1095	1083	1071	1060	1049	1038	1027	1017	1006
2.35	1140	1127	1114	1102	1090	1078	1066	1055	1043	1032	1022	1011	1001	991
2.40	1122	1109	1097	1084	1072	1061	1049	1038	1027	1016	1005	995	985	975
2.45	1105	1092	1080	1067	1056	1044	1033	1022	1011	1000	990	980	970	960
2.50	1089	1076	1064	1052	1040	1029	1018	1007	996	986	975	965	956	946
2.55	1073	1061	1049	1037	1026	1014	1003	993	982	972	962	952	942	932
2.60	1057	1045	1033	1022	1010	999	988	978	967	957	947	937	928	919

TABLE 7			COST OF BRICK MASONRY PER CUBE							
			Cost with mortar thickness used in practice - Bt				Cost with 10 mm mortar thickness - Bt			
Length	Average Height	Cost 1000 Bricks	Brick	Mortar	Labour	Total Rs	Bricks	Mortar	Labour	Total
(a) 7.3	1.9	450	776	1219	493	2488	1026	872	651	2549
7.4	1.9	475	810	1200	487	2497	1069	851	643	2563
7.5	1.95	500	828	1175	473	2476	1088	823	621	2532
7.6	2.1	525	816	1131	444	2391	1060	785	577	2422
7.7.	2.1	550	845	1114	439	2398	1096	764	570	2430
7.8	2.1	550	836	1096	434	2366	1084	743	563	2390
7.9	2.15	575	851	1071	422	2344	1097	715	545	2357
8.0	2.2	600	863	1045	411	2319	1109	688	525	2322
8.1	2.25	600	839	1021	400	2260	1076	639	506	2221
8.2.	2.25	625	865	1002	396	2263	1108	614	491	2253
8.3	2.3	650	877	974	386	2237	1118	614	491	2223
(b) 8.7	2.6	650	770	860	338	1968	990	605	435	2030
(c) 8.7 *	2.6 *	700	843	897	345	2085	1066	605	435	2106
COST SAVINGS (Rs)		(a)-(b)	+ 6	359	155	520	36	267	216	519
		(a)-(c)	- 67	322	148	403	- 40	267	216	443
Bt = 0.84" ; St = 0.9" ; Ht = 0.88"							Bt = 0.39" (10mm) St = 0.9" ; Ht = 0.88"			

* Standard brick

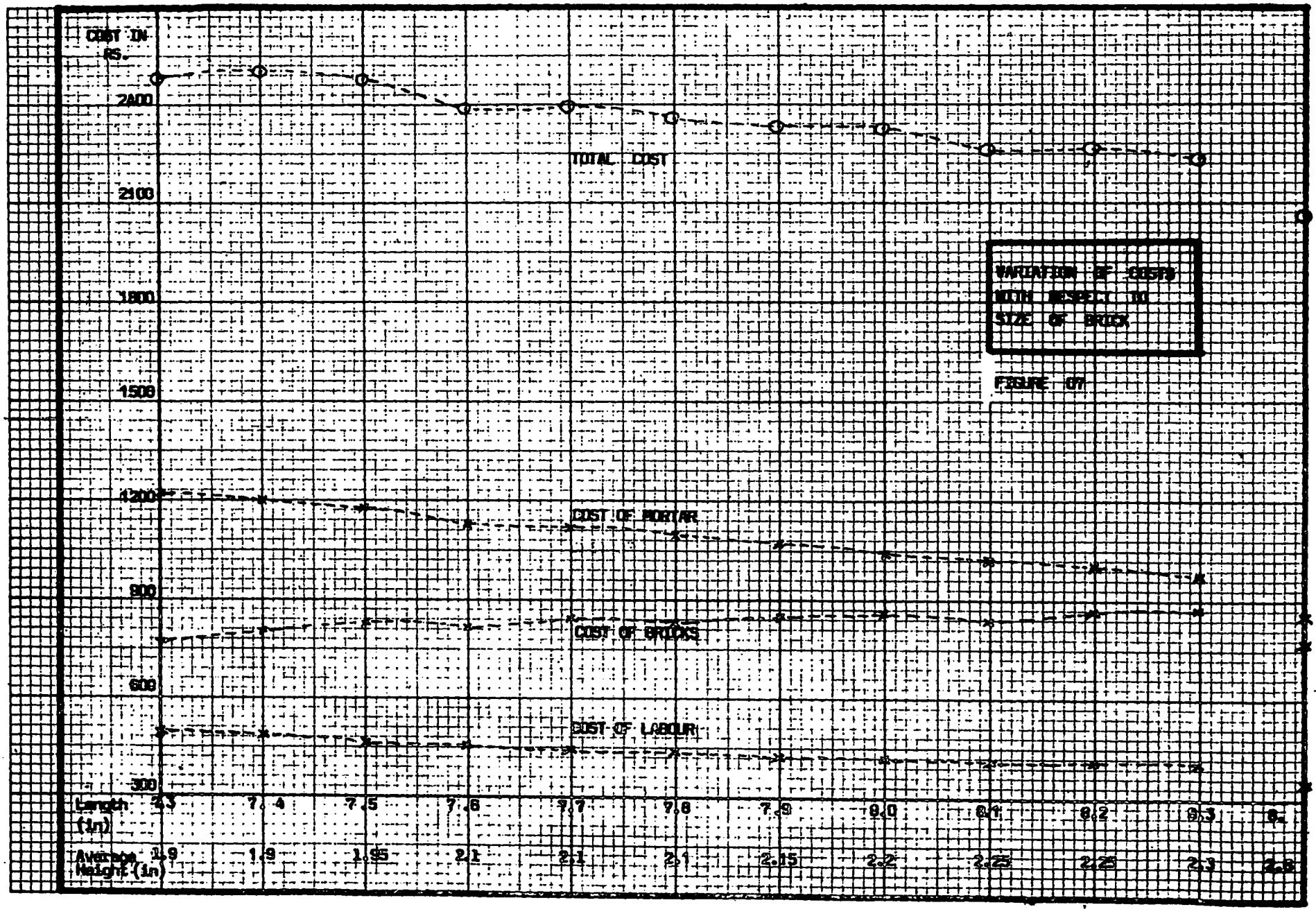

COST IN RS.
2400
2100
1800
1500
1200
900
600
300
TOTAL COST
COST OF MORTAR
COST OF BRICKS
COST OF LABOUR
VARIATION OF COSTS WITH RESPECT TO SIZE OF BRICK
Length (in)
7.4
7.5
7.6
7.7
7.8
7.9
8.0
8.1
8.2
8.3
Average Height (in)
1.9
1.9
1.95
2.1
2.1
2.1
2.15
2.2
2.25
2.25
2.3

FIGURE 07

Rates (2), to lay 1450 bricks is as follows:

3 days Mason @ Rs.80/- = Rs.240/-
5 days Labour @ Rs.40/- = Rs.200/-
Total for 1450 bricks = Rs.440/-
Cost of labour per brick = Cts.-/30

∴ Total labour cost to lay 1586 bricks = 1586 x 0.30
Rs.476/-
========

Cost of Mortar per Cube

Volume of 1586 bricks $= \frac{1586 \times 7.3 \times 3.56 \times 2.0}{12 \times 12 \times 12}$
= 47.7 c.ft.
Volume of mortar per cube = 100 - 47.7
= 52.3 cu.ft.

In order to calculate the cost of mortar of mix 1:5 consider the procedure shown below:

No. of standard bricks per cube = 1450
Volume of 1450 such bricks $= \frac{1450 \times 8.75 \times 4.1 \times 2.6}{12 \times 12 \times 12}$
= 77.82
Volume of mortar = 100 - 77.82
= 22.18 c.ft.

Materials for 22.18 cu.ft. as given in the BSR is follows:

Cement 3.7, 50 kg. bags @ Rs.120/- = 444.00
Sand 23 c.ft. @ Rs.275/- = 63.25
Water 20 gls. @ Cts-/25 = 5.00
= 512.25
Hence cost per cubic foot $= \frac{512.25}{22.18}$
= Rs.23/-

Hence the cost of mortar = 23 x 52.30
= Rs.1,203/-
==========

Total Cost

Cost of Bricks = Rs. 750
Cost of Labour = Rs. 476
Cost of Mortar = Rs.1203
Rs.2429
=======

Analysis of Cost Variations with Different Brick Sizes

Table 7 shows the variations of costs with respect to different brick sizes. A plot of these costs are shown in Figure 7. The brick sizes assumed correspond to the average values shown in the top most cage of Figure 5.

Consider a brick size of 7.3" x 3.59" x 1.9". The reduction in cost when compared with a standard brick is Rs.403/- as seen from Table 7. (2488 - 2085 = 403). This is the additional amount which could be paid for the purchase of standard brick so that the cost of construction does not exceed that when 7.3" x 3.59" x 1.9" bricks are used. As the total number of standard bricks per cube is 1204 including wastage, the break even price for 1000 standard bricks = $700 + \frac{403}{1.204}$ = Rs.1,034/-.

TABLE 8

Length	Average Height	Cost of 1000 bricks (Rs)	Break even Price for 1000 standard bricks (Rs)	% reduction from total basic cost of std. brick
7.3	1.9	450	1034	19.3 *
7.4	1.9	475	1042	19.8
7.5	1.95	500	1024	18.8
7.6	2.1	525	954	14.7
7.7	2.1	550	960	15.0
7.8	2.1	550	933	13.5
7.9	2.15	575	915	12.4
8.0	2.2	600	894	11.2
8.1	2.25	600	845	8.4
8.2	2.25	625	848	8.5
8.3	2.3	650	826	7.3

* From Table 7 : $\frac{2488 - 2085}{2085}$ = 19.3

Cost Savings

It must be amply clear by now that the use of a larger brick size brings forth a considerable cost saving and may even make the difference of either winning a tender or loosing a tender. To put it in another way, a cost saving of Rs.520/- amounts to employing an additional gang of 4 masons and 5 labourers.

The Kiln Survey revealed that there is no difficulty in purchasing large size bricks as most brick manufacturers stated that they could supply larger size bricks if necessary. However, most of them stated that they would require an advance from the purchaser and delivery period of about 1½ months to 2 months.

Cost Savings through Efficient Methods of Construction

Concreting Columns after the Construction of Brick Walls

Fixed Column Size

When brick walls are constructed, internal joint thickness in strecher courses (v) can be varied to suit the column as shown in Figure 8. Therefore, the brick wall can be constructed first (as would be acceptable in certain situation) and thereafter concreted as shown in Fig. 9.

Cost savings could be achieved as a result of less formwork and less labour.

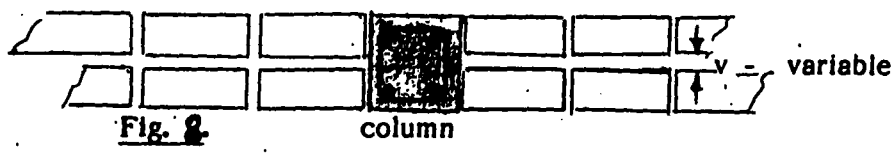


Fig. 8

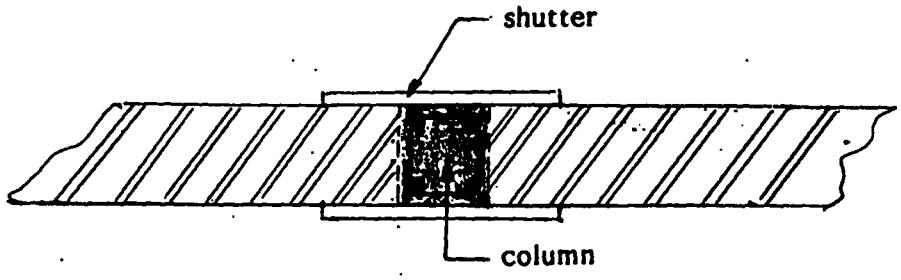


Fig. 9.

Variable Column Size

In contrast with the above method of construction, the dimensions of the column can be adopted to be compatible with dimensions of brick sizes as shown in Figure 10.

Other Methods of Construction

There are many methods of constructing a 9" thick brick wall. The methods described below are generally not used in Sri Lanka, but could be expected to bring worthwhile savings. However, the relative economies of these methods need detail investigation and as such this aspect is not discussed.

Corner Method of Construction

In this method of construction, corners of a brick wall are first built as shown in Figs. 5 & 6 upto a height of about 18 courses. If necessary, a gauge staff can be used to achieve the specified bed

mortar thickness etc. As a result of the different brick sizes found in the construction industry, it may not be possible to have a standard staff; instead heights of different courses of brick work will have to marked on site depending on the height of bricks which will be used.

Once the corners are constructed the mason will have to use a line between the two corners to act as a guide for laying the courses of brickwork. For this purpose a wooden corner block as shown in Figure 6 below can be used. If the length of the wall is greater than about 25' - 30', it may be necessary to use a metal tingle plate as shown below or similar device (eg. a nail). Generally the use of more than one tingle on a long wall should be avoided as it could lead to "waiving" in the courses of brickwork.

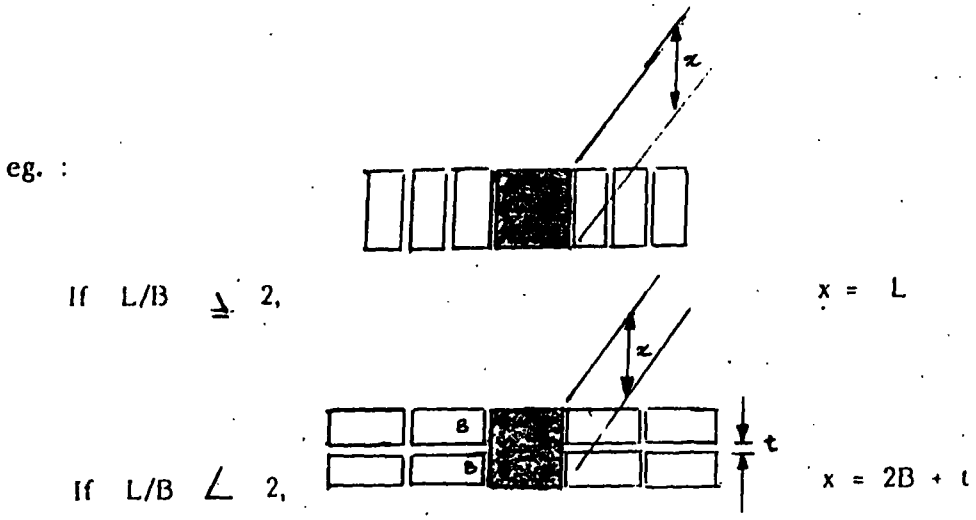


Figure 10

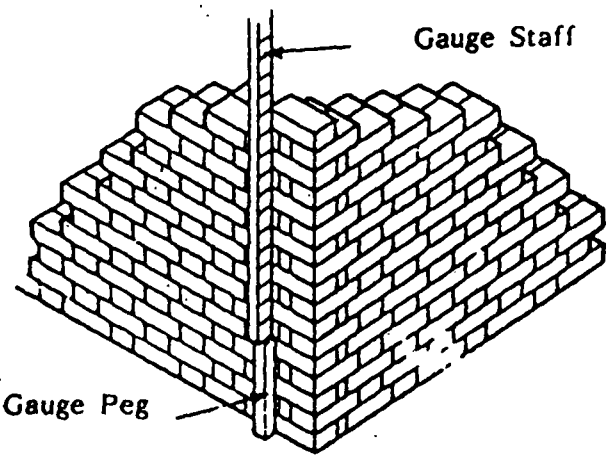
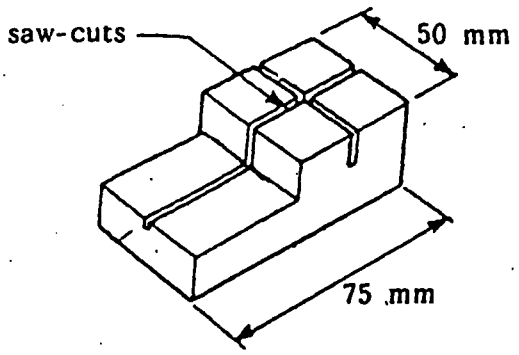
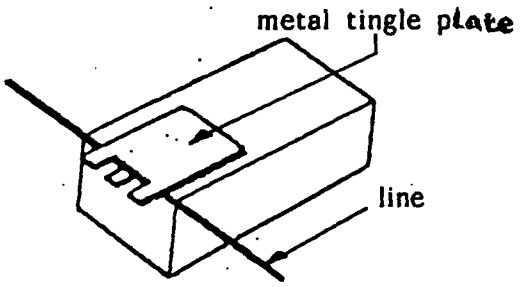


Figure 11



Wooden Corner Block



Metal Tingle Plate

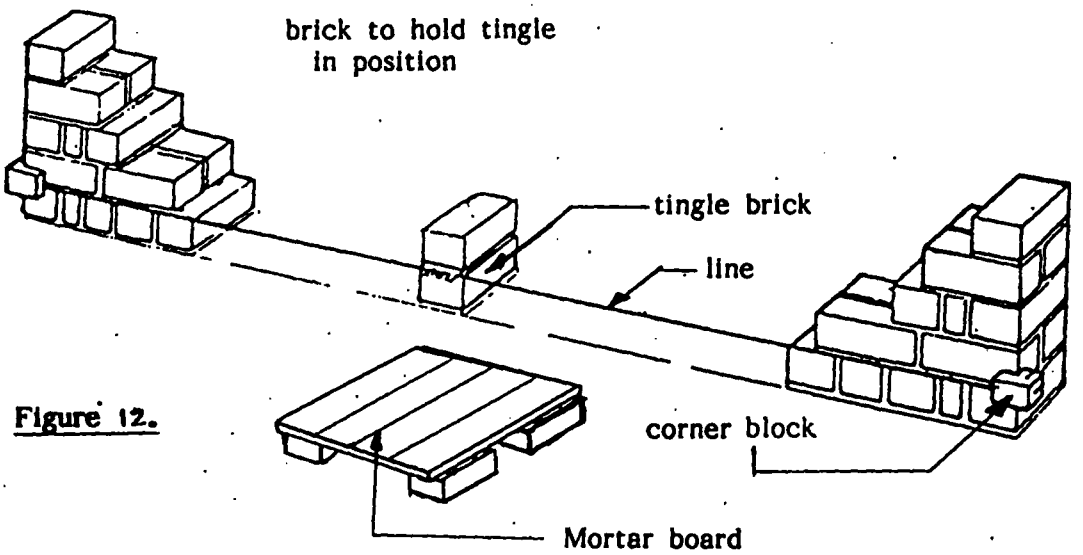


Figure 12.

Over-Hand Method of Construction

It is a common practice in Sri Lanka to use 2 masons on either side of a wall to construct a 9" brick wall. In contrast, the method of using masons only on one side and working "overhand" is considered to result in greater cost saving.

Furthermore, the current method of construction sometimes results in the mason making the wall plumb on both sides. This is unnecessary as it is sufficient to make the wall plumb only on one side. The over-hand method of construction eliminates this practice completely.

Still further, the over-hand method of construction eliminates the necessity to have sacffolds on either side.

All these features of the over-hand method of construction could be expected to bring considerable cost savings.

Work-Area Organisation

Ample evidence can be provided (3) to prove that this is an area where considerable improvements can be made. It is needless to state that each additional movement, blockages, etc. decreases construction productivity thus increasing the cost of construction. Some simple precautions, which will bring considerable cost savings are given below.

a) Stack bricks within easy reach of the mason along the length of the wall before work commences.
b) Raise mortar boards above the

ground level; the space underneath the board can be used to shove-in broken pieces of bricks etc.

c) Space mortar boards at the corners of the wall/walls not more than 9' - 10' apart along the wall length.

d) Level the ground off for easy working : This aspect is often neglected.

e) Place mortar boards approximately 2' - 2½' from the face of the wall or about 3 "foot-lengths" of the mason who is constructing the brick wall.

f) Keep the gangways, access-ways etc. clear without any blockages: often free movement is hindered with bamboos, planks with nails, broken bricks, water barrels etc. scattered all over.

A general layout of a working area is shown in Figure 13.

A general layout of a working area is shown in Figure

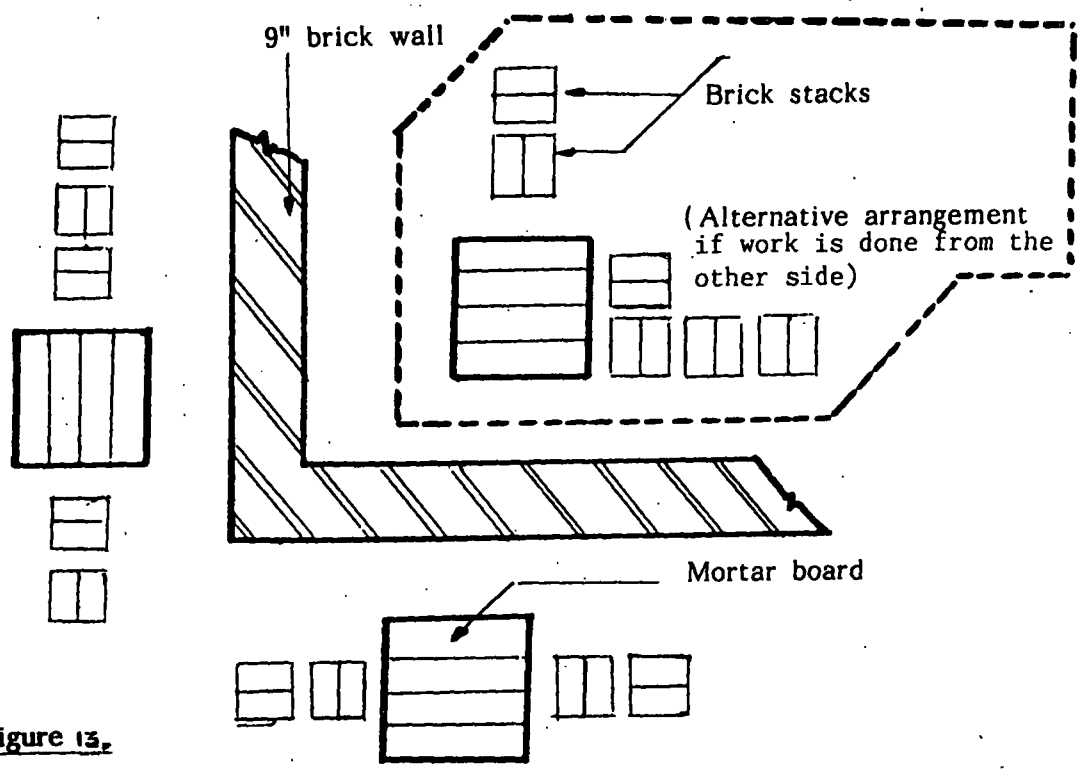


Figure 13.

Additional Care to ensure Walls are Plumb

Under normal circumstances, it would be preposterous to discuss this aspect. However, considering the level of workmanship in the industry this aspect needs to be highlighted. As a results of walls not being plumb, plasters as thick as 3" are seen today in the construction industry (3). Hence, additional care must be taken to ensure that walls are plumb, as it would bring forth considerable cost savings.

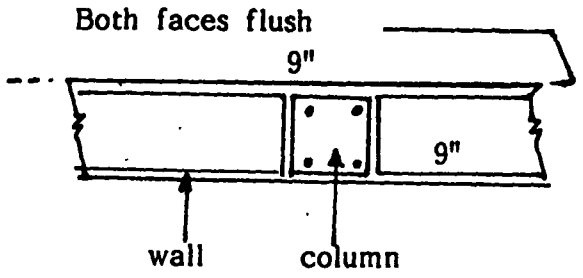
Application of Work Study Techniques

Considerable saving could be achieved by the application of work study techniques to improve productivity of a given construction operation. No attempt is made here to discuss this aspect.

Cost Savings by Reducing Wall/Column Thickness

The necessity to construct 9" thick walls generally arises (although not necessarily so always) due to

an aesthetic consideration for the wall surface and the column surface to be flush as shown below.



This practice results in unnecessary expenditure as a result of using a thicker wall and to an lesser extent, as a result of using a larger column size.

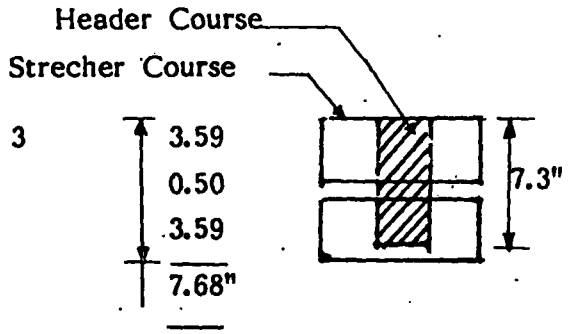
The possible methods of reducing the wall thickness is discussed below. If however, the column size cannot be reduced to suit the wall thickness so that both surfaces could be flush after finishing a larger column size and a reduced wall thickness could be used, with the protruding column constructed as an architectural feature.

Cost Saving through the Reduction of Wall Thickness

Construction of Walls in English Bond

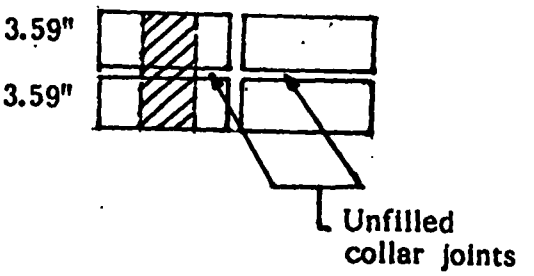
The most common 'bond' used for construction of super-structure brick walls is the english bond which consists of alternate courses of strechers and headers. This bond is considered to be the strongest for super-structure walls.

a) As an example consider a brick size of 7.3" x 3.59" x 1.9". Assuming a vertical joint thickness of ½", the cost-effective thickness of wall could be considered to be 7.68" as shown below.



This is an reduction of 1.32" (9 - 7.68) from 9" and amounts to a reduction of about 14.6% of the total volume of brick-work which in turn brings forth an equal amount of reduction in costs. If a smaller brick is used, a further reduction in cost could be achieved.

b) Research has shown that unfilled vertical joints does not have a significant effect on the strength of brick walls. As such further economies could be achieved as shown below.



Hence a 9" wall thickness can be reduced to 7.3" with a total reduction of cost on the range of 18%. The reduction of cost for bricks of other sizes could be similarly deduced.

Construction of Walls in Strecher/Header Bond

In walls constructed using the strecher bond, all courses are strechers. Similarly, in walls constructed using the header bond, all courses are headers. As such in walls using these bonds for construction, although not strong as walls in english bond, problems of dimensional variations. (re. variations in lengths, variations in breadths etc.) can easily be counteracted. The reasons for this should be quite obvious. As explained in (a) walls with smaller thicknesses can be constructed, resulting in a cost saving.

If necessary walls in strecher bonds could be also constructed without a filled collar joint as explained in (b) resulting in further cost savings.
Furthermore, it is generally considered

that walls in strecher bonds are made easier to construct than walls in other bonds still further the over-hand method of construction could be used easily. Therefore, it may be advantageous to construct walls in strecher bond as it will bring forth further cost savings. However, research is required to confirm this opinion.

Please note that strength of walls in strecher bond could be increased by introducing a header course (say once in 5 strecher courses of appropriate)

Use of Non-standard Small Bricks

It should be clear by now that the use of smaller size bricks bring forth cost savings, as a result of a reduced wall thickness.

It should be pointed out that the use of smaller size bricks reduces loads or floors, beams and foundations, etc. In other words the design loads would be reduced and consequently a greater cost saving could be expected by considering the economy of the whole structure.

Hence, it can be concluded firmly, that there is a strong case for the existence of non-standard small brick, as shown earlier. Apart from the aspect of costs, it would also enable an efficient utilisation of limited resources, especially clay.

Cost Savings through the Reduction in Column Thickness

As discussed in the introductory passage (Cost Savings by Reducing Wall/Column Thickness), cost savings can be achieved as follows:

a) reduction in volume of concrete and formwork.

b) reduction in cost of construction by adopting a column size to suit the wall thickness and explaining the method of construction

Serviceability Problems due to Reduction of Wall thickness

It must be pointed out that as a result of reducing the wall thickness some serviceability problems may crop up such as narrow reveals which may tend to spall-off easily, reduction in sound insulation, reduction in resistance to water penetration etc. Nevertheless, cost effective solutions could be found or are available if necessary, to overcome these problems.

The Effect of Reducing Joint Thicknesses on Cost of Construction

It was shown in Section (Cost Savings by the Use of Large/Standard Size Bricks) that the joint thicknesses in use are frequently in excess of the value specified in the Specifications.

A further examination of Table 7 would show that a reduction of bed joint thickness from 0.844" to 0.39" does not bring forth considerable cost savings. Especially for smaller brick sizes, there does not seem to be any cost saving by reducing the bed mortar joint thickness as seen from Table 9.

Furthermore, the use of a smaller joint thickness may at times require sand to be sieved in order to eliminate the larger particles, etc. This will result in increased labour costs and increased material cost as a result of more wastage due to sieving. Therefore, taking all these into consideration it could be concluded that the use of a smaller joint thickness does not reduce cost but increases cost.

Cost Savings by Purchasing Construction Materials in Advance

It is a known fact that during rainy seasons that prices of bricks and sand go up. At times, the price variations for bricks would be around Rs.100/- per 1000, which is an increase

TABLE 9		
Length	Cost Savings per Cube	
	Height	Cost Savings (Rs)
7.3	1.9	- 61
7.4	1.9	- 66
7.5	1.95	- 56
7.6	2.1	- 31
7.7	2.1	- 32
7.8	2.1	- 24
7.9	2.15	- 13
8.0	2.2	- 3
8.1	2.25	+ 39
8.2	2.25	+ 10
8.3	2.3	+ 14
8.7	2.6	- 62

of about 25%. Same could be said of sand as such, purchasing these materials during rainy periods would certainly not bring any cost savings but would only inflate the cost. Hence, the right decision to make would be to purchase these materials well in advance of the rainy periods.

This would necessitate cash on purchase unlike other construction materials where better credit facilities are available for the buyer. Contractors plagued with cash flow problems would find this very difficult, if not an impossible pre-position. Financing facilities available to Construction Contractors today are by no means favourable as interest rates could be as high as 25%, even if available. However, it will be still profitable to purchase these materials in advance as shown below especially for those contractors who are paid for 'materials - on - site'.

Consider the purchase of 1000 brick at Rs.400/-.

Assume a pay back period of 3 months.

Interest payment $= 400 \times \frac{25}{100} \times \frac{3}{12}$

$= Rs.25/-$

Price fluctuation due to rain = Rs. 50 - 100

Cost Saving per 1000 = Rs. 25 - 75

Cost Savings Through the Use of Different Mortars

The percentage cost of mortar with respect to the total basic cost is tabulated in Table 10.

As seen from Table 10 the percentage of cost of mortar appears to range from a high 43-49. Section (Cost of Mortar per Cube) shows that the

TABLE 10		
Length (inches)	Average Height (inches)	% Mortar Cost
7.3	1.9	48.9
7.4	1.9	48.1
7.5	1.95	47.5
7.6	2.1	47.3
7.7	2.1	46.5
7.8	2.1	46.3
7.9	2.15	45.4
8.0	2.2	45.1
8.1	2.25	45.2
8.2	2.25	44.3
8.3	2.3	43.5
8.7	2.6	43.7

cost of cement is about 87% of the cost of mortar. Hence, the cheaper substitute for cement should bring forth considerable savings in cost.

Use of Clay Mortar

In the past and present brickwalls have been constructed by using clay and sand as a mortar. An examination of some brick walls so constructed was found to be in a satisfactory condition. As such clay could be used as a substitute for cement. A relative comparison of the cost of the two materials is given below:

Cost of a tractor load of clay including transport (75 c.ft) = Rs.130-175
Cost of 50 kg bag of cement including transport (1.25 c.ft) = Rs.120

Therefore, it should be very clear that by using clay as a substitute for cement considerable cost savings could result as far as the cost of material is concerned. Also note that, if necessary a little quantity of cement could even be introduced for this mix.

Consider now the cost of labour. This would be obviously more than the cost of making use of cement mortar. However, cost savings from clay mortar could be expected to out-weigh the increase in the labour cost.

As such, the total cost of construction could be expected to be less than when cement mortar is used. However, detailed studies would be required to comment on the extent of cost savings.

Use of Lime Mortar

Lime is another substitute for cement. Mixes such as 2 of lime and 5 of sand have been used in the past. A comparative analysis of the different cost of materials is given below:

Cost of 1 cube of hydrated lime
= Rs.2,000/-
Hence, cost of 1 c.ft. of hydrated lime
= Rs. 20/-**
Cost of 1.25 c.ft. of cement
= Rs. 120/-
Hence, cost of 1 c.ft. of cement
= Rs. 96/-**

Therefore, it should be obvious that the cost of mortar could be reduced by about 50% if lime is used as a substitute for cement.

Cost Savings through Market Serveys

As stated earlier price data obtained from the site survey and kiln survey

are plotted in Figure 4. If the patterns of the sub graphs are analysed, it should be amply clear that some buyers purchase bricks at a more competitive price than others (leaving aside other factors like negotiating abilities etc) and as such make more savings than the others. Therefore, it should be obvious that a proper market survey would bring considerable cost savings and in order to accomplish this objective, various details regarding brick manufacturers, including addresses are available with the Author.

It was also stated earlier that tenders were called for the supply of standard bricks. A list giving details of brick manufacturers from the information so obtained are available with the Author. This too would enable a prospective buyer to carry out a better market survey and thereby create an opportunity to achieve cost savings.

Cost Savings through the Use of Common Clay Bricks as a Facing Brick

Generally, the common clay brick available in the market is not suitable to be used as a facing brick. The only facing brick used until recently was the "wire-cut" brick. However, during the last few years, few different types have been used which are much cheaper than the wire-cut brick.

Some of the problems inhibiting the use of the common clay brick as a facing brick is due to its poor surface texture and variability of size. The latter could be got over to some extent by purchasing bricks directly from a kiln and from the same lot (i.e. from a lot fired at a time). As regards to the texture, it could be improved by applying a colourless paint on the brick.

Summary of Salient Points of Cost Advice

1 Bricks of standard size when used for the construction of 9" thick walls bring forth cost savings in the range of about 7 - 20%.

2 Bricks larger than standard size also bring forth cost savings.

3 Thickness of single brick walls need not necessarily be 9" : it could be reduced to a minimum dimension given by the greater of the length of brick or twice the breadth. For this purpose, smaller brick sizes could be used as discussed which will bring forth considerable cost savings sometimes amounting to as much as 18%. Furthermore, as a result of the reduced design loads on structural elements further cost savings could be achieved with respect to the overall economy of a project.

4 Whenever possible reduce the size of 9"x9" columns to correspond with reduced wall thickness. When it is not possible, the protruding column faces could be made into an architectural feature.

5 Cost of construction could also be reduced by constructing walls in strecher bond and/on with unfilled collar joints.

6 Use figures 1 & 4 to check whether bricks are purchased cost-effectively.

7 Place orders directly with brick manufacturers to obtain required sizes. This may necessitate the payment of an advance. As bricks are not available ex-stock a delivery period of about 1½ months to 2 months will be necessary and as such orders will have to be placed well in advance.

8 The reduction of bed joint thickness increases the cost of construction marginally; The joint thicknesses used in the industry today appears to be cost-effective.

9 Employ efficient methods of construction: Concreting columns monolithically with the brickwall (re. after construction of brick walls), corner method of construction, over-hand method of construction, efficient organisation of work area and application of work study techniques would all bring

forth considerable savings in cost.

10 Use of different types of mortar, especially clay mortar or lime mortar will bring forth savings in cost: Use of lime mortar could redece costs by about 20%.

11 Purchase materials well in advance of the rainy seasons. Cost savings could be in the range of 6 - 18% of the price of bricks in dry periods.

12 Carry out market surveys before embarking to purchase bricks.

13 Use common clay bricks as a facing brick when acceptable. Bricks purchased from the same kiln as a lot (ie. full production at one firing) could facilitate its usage.

Acknowledgement

The Author is grateful to the Director General of the Institute for Construction Training & Development (ICTAD) and to all staff and other employees of the Development Division of ICTAD for the assistance given in connection with this study.

References

1. Bogahawatte, V.T.L. - Non Mechanized Brick Making in Sri Lanka. NBRO.

2. Building Schedule of Rates, Department of Buildings.

3. Audio Visual Film on Site Organisation, Mobile Development Unit, Development Division, Institute for Construction Training and Development.

4. Abeysekera, W.V.K.M. - Application of Works Study Techniques in Building Projects - Seminar on Construction Planning, Centre for Housing Planning & Building - 1986.