CENTRAL BUILDING RESEARCH INSTITUTE, ROORKEE-247667 (INDIA)

# BUILDING RESEARCH NOTE

BRN - 44

## MANPOWER & MATERIAL REQUIREMENTS FOR OFFICE BUILDINGS

### Introduction

An estimate of material and lobour inputs is generally required for projects prior to the start of actual construction for purpose of budgeting, calculation of cost index, justification of tenders etc, Computation of these quantities is normally based on the percentage of total cost of building which an individual material of labour will use up. This method may not give the realistic results because these percentages are usually assumed to be same for all types of buildings which never occur and also these may vary from time to time and place to place depending upon the market prices of various items. The alternative method of computation of the quantities is to prepare detailed estimate/ bills of quantities and then calculating the requirements with the aid of material and labour constants usually derived from the analysis of rates This method, though ideal, is very time consuming and also requires complete set of drawings, designs, specifications and other detailings in advance which are not normally available in most of the departments due to procedural difficulties. Studies have been carried out at the Institute to evolve a quick method of estimation of material and labour requirements. Simple Statistical equations have been worked out which relate the consumption of each material/labour to plinth area of the building. Such equations have been derived for office buildings and their uses are illustrated in this note. The study is applicable to 4-10 storeyed office buildings (framed construction) with plinth area varying from 1600 to 26000m$^2$

### Basis of calculations

The basic requirement for the study is to know the exact quantum of material and labour which has actually been used for completion of various projects with varying plinth area so that the consumption of each material and labour can be related to a range of plinth areas. In order to arrive at an accurate consumption of material/labour, the analysis has been based on the final bills of completed buildings which were collected from various constrution agencies in Northern India, The final bills were analysed with the help of average material and labour constants.

### Specifications and Computation

It was observed from the data that all the office buildings were framed structures ranging from 4-10 storeyed construction with plinth area varying from 1600 to 26000m$^2$. A single set of relationships has been established from the data irrespective of the number of storeys in various projects. Separate relationships could not be establisned for different number of storeys due to difficulty in getting sufficient data for each category of building (storeywise). However. due care has been taken for making adjustments in elements like foundation etc.

The survey of the final bills revealed that some times different specifications were adopted for the same element of the building in different projects. To form a uniform basis for the analysis, a set of reference specifications was prepared based on most commonly adopted specifications in various projects. The date were adjusted to these specifications and computations maee accordingly. These specifications are shown in Appendix-A. The effect of the shape of the building on the consumption of materials/labour has been taken care of by considering a number of buildings with different configuration so as to project out fairly average consumption. It was observed that the storey height also varied from project to project. The computations were made with an average storey height of 3.10m. The type of foundation for a structure mainly depends upon the bearing capacity/nature of soil, load, type of structure etc. Two types of foundations viz. column footings and raft foundation were met with in the data. Analysis for the statistical relationships were based on the column footings and the additional quantity of RCC work including reinfocement was worked out in case quantities for raft foundation had to be computed. Number of storeys in a building has direct impact on the consumption of materials and labour for roofing items of a building, Since a single set of relationships has been established irrespective of the numbers of storeys in a building, roof treatment has altogether been omitted in order to avoid non-uniform distribution of materiais/labour for roofing items. In case of reinforcement, computations were made assuming as if the total reinforcement was in the form of deformed bars. However, the requirement of mild steel was also given in terms of percentage of total reinforcement.

**Statistical Relationship**

The quantities of various items of works were collected from the final bill of each building. Each item of work was then analysed in terms of materials and labour with the help of average material/labour constants. Similar materials and labour were totalled in order to arrive at their total consumption for each building. The exercise was done for all the buildings which were having different plinth areas. This analysis has revealed the comparative consumption of each material and labour in different buildings. Based on the quantities computed for these buildings with different plinth areas, relationships were established statistically for each material/category of labour against the plinth area of these buildings. In all relationships for twentyone materials and six categories of labour have been established which are applicable to plinth areas ranging from 1600 to 26000m². These are given in Table 1. The requirement of any material/labour can be computed by putting the total plinth area 'A' (plinth area of all the floors of the building) in the respective equation. The relationships have been given only for the important materials/labour which comprise the major portion of the building cost.

No attempt has bean made to derive relationships for rain water pipes, door and window fittings. However, one 100mm dia. rain water pipe with necessary accessories may be taken for 40 m² of roof area as per IS:3036-1965 Code of Practice for laying lime concrete for water proofed roof finish To account for the cost of door and window fittings, either lump sum amount may be added or the actual number of flttings may be calculated based on the number of doors and windows in the proposed building This is elaborated in Appendix 'B'. Certain items such as centering, shuttering and scaffolding do not form part of the building but are essentially required during the course of construction. As far as centering and shuttering is concerned, the requirement of timber and ballies has been included in the relationships (Table-I). For scaffolding, the labour contents involved have been reckoned in these relations but materials have not been taken into account due to its complexity in use. The cost of materials may be either on the basis of percentage of total cost of building or lump sum amount may be considered while computing the cost of the building.

**Uses**

The study is useful for quick estimation of materials/labour which can be made use of for material budgetjng justification of tenders, calculation of cost indices, computation of

building cost etc. To illustrate the above uses quantities have been worked out for a five storeyed building with 10000m$^2$ plinth area. This is shown in Appendix-B. Such computations can serve as a useful guide to the owner/builder/engineer for budgeting and procurement of materials. The same calculations may be used for the purpose of justification of tenders as well. For this the important materials and labour may be priced with the rates which were taken at the estimation stage and also with the prevailing market rates. From the ratio of the two actual increase/decrease in building cost can be calculated and compared with the tendered percentage on or off the estimated cost For computation of building cost all the materials and labour thus calculated may be priced with the current market rates. Provision should also be made for the cost of rain water pipes, door and window fittings, scaffolding, water charges and contractors' overheads and profit. Such calculations based on Roorkee rates are illustrated in Appendix-B, which are self-explanatory. Computation of cost indices has also been shown in Appendix-C The cost index at Roorkee for the year 1996 has been worked out with the base year 1993 at Roorkee. Only important materials/labour need be considered for such computations.

**Concluding Remarks**

The method proposed for computation of material/labour inputs for office buildings is simple and straightforward. It can be used for efficient planning and sufficiently accurate estimates of materials/labour requirements. It advances a more rational approach for computation of building cost and price indices,

Prepared by : G.C. Sofat
Revised by G.C Sofat - 1996
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TABLE - 1

STATISTICAL RELATIONS

| S. N. | Material/Labour | Unit | Statistical Relations |
|---|---|---|---|
| 1. | Cement | tonnes | 0.1925 A + 18.52 |
| 2. | Fine Sand | cu m | 0.03 A + 105.5 |
| 3. | Coarse Sand | cu m | 0.2592 A — 80.94 |
| 4. | Coarse aggregate 20 mm Nom. Size | cu m | 0 2728 A — 48.50 |
| 5. | Coarse aggregate 10 mm ,, | cu m | 0.1164 A — 20.74 |
| 6. | Coarse aggregate 40 mm Nom. Size | cu m | 0.0151 A + 73.91 |
| 7. | Brick ballast 25 mm Nom. Size | cu m | 0.0426 A — 38 37 |
| 8. | Timber for formework | cu m | 0.005 A + 11.19 |
| 9. | Timber for Joinery | cu m | 0.0024 A — 0.53 |
| 10. | Ballies | m | 0.5507 A + 797 75 |
| 11. | Bricks | %Nos | 1.1829 A — 524 23 |
| 12. | Deformed bars | tonnes | 0 0479 A |
| 13. | Door Shutters | sq m | 0 0636 A — 17 07 |
| 14. | Window Shutters | sq. m | 0.1117 A + 93 26 |
| 15. | Glass | sq m | 0.1407 A + 55 99 |
| 16. | Primer | Lit | 0 0256 A + 9 7 |
| 17. | Paint | Lit | 0.0322 A + 7.24 |
| 18. | Lime | qtls | 0.0754 A — 51.21 |
| 19. | Surkhi | cu m | 0.0204 A — 18 39 |
| 20. | Marble chips | qtls | 0.1338 A — 48 52 |
| 21. | Marble Powder | cu m | 0 0012 A — 0 36 |
| 22. | Mason | working days | 1.1314 A — 407 4 |
| 23. | Carpenter | —do— | 0.7094 A + 449 09 |
| 24. | Glazier | — do— | 0 0122 A + 10 31 |
| 25. | Painter | — do— | 0 0905 A + 37.26 |
| 26. | Blacksmith | —do— | 0 479 A |
| 27. | Beldar | — do — | 6.055 A — 2024 37 |

NOTE :— ( i ) A is the total plinth area ($m^2$) of all the floors of the building

(ii) The relations are applicable for a range of 1600 $m^2$ to 26000$m^2$ plinth area.

(iii) The type of foundation considered is column footings.

(iv) The relation for reinforcement has been given in terms of deformed bars, 10 to 20% of this reinforcement may be taken as mild steei.

## SPECIFICATIONS

| S. N. | Element/Item of work | Reference specifications adopted for the Study |
|---|---|---|
| 1. | Foundation | *Excavation in ordinary soil.<br>*R.C.C. Column footings with P.C.C. 1:5:10 (1 cement : 5 fine sand 10 graded stone aggregate 40 mm nominal size in beds.<br>*Sand filling in plinth under P.C.C. beds :<br>*Brick work in cement mortar 1 : 6 (1 cement : 6 coarse sand) using traditional bricks. |
| 2. | Frame | Reinforced cement concrete frame including finishing and plastering the exposed surface with cement mortar 1 : 3 (1 cement : 3 fine sand) of thickness not exceeding 6 mm to give a smooth and even surface. |
| 3. | Walling | *Brick work in cement mortar 1 : 6 (1 cement : 6 coarse sand) using traditional bricks.<br>*Half brick work in cement mortar 1 : 3 (1 cement : 3 coarse sand) with hoop iron reinforcement for partitions.<br>*Reinforced Cement Concrete work for lintels, Chajjas, fins including finishing and plastering the exposed surface with cement mortar 1 : 3 (1 cement : 3 fine sand) of thickness not exceeding 6 mm to give a smooth and even surface. |
| 4. | Flooring | Terrazzo (Marble chips) flooring laid insitu, as follows :-<br>*10 cm thick P.C.C. 1 : 5 : 10 (1 cement : 5 fine sand : 10 graded stone aggregate 40 mm nominal size) subgrade for ground floor and 5 cm thick cushionrng layer of lime concrete using brick aggregate of 25 mm nominal size and 50% mortar comprising of 1 Lime ; 2 Surkhi on R.C.C. slab for upper floors.<br>*40 mm thick marble chips flooring, rubbed and polished to granolithic finish (Machine grinding), underlayer 31mm thick cement concrete 1 : 2 : 4 (1 cement : 2 coarse sand : 4 graded stone aggregate 10mm nominal size) and top layer 9mm thick with marble chips laid in cement with marble powder mix 3 : 1 (3 cement : 1 marble powder) by weight in proportion of 4 : 7 (4 cement marble powder mix : 7 marble chips) by volume).<br>*21mm thick marble chips skirting rubbed and polished to granolithic finish underlayer 15 mm thick cement plaster 1 : 3 (1 cement : 3 coarse sand) and top layer 6 mm thick with marble chips laid in cement and marble powder) by weight in proportion of 4 : 7 (4 cement marble powder mix : 7 marble chips) by volume. |
| 5. | Structural Floor/Roof | Reinforced cement concrete slab including finishing and plastering the exposed surface with cement mortar 1 : 3 (1 cement : 3 fine sand of thickness not exceeding 6 mm to give a smooth and even surface. |
| 6. | Joinery | Doors :<br>Wooden frames 100×60 mm for doors with 40×3 mm flat iron hold fasts 40 cm long and embedded in 30 10×15 block of P.C.C 1:3:6 (1 cement : 3 coarse sand : 6 grade stone aggregate 20mm nominal size).<br>*35 mm thick flush door shutters, non decorative type.<br>Windows :<br>*Steel glazed windows of standard rolled steel sections<br>*12 mm thick cement plaster 1 : 6 (I cement : 6 fine sand on smooth face on brick walls.<br>*20 mm thick cement plaster 1 : 6 (I cement : 6 fine sand) on rough face of brick walls. |
| 7. | Finishes | *White wash/colour wash both internally and externally.<br>*Painting on doors and windows over a coat of primer |

## COMPUTATION OF BUILDING COST FOR A BUILDING WITH 10000M² PLINTH AREA

| S.N. | Material/Labour | Unit | Statistical Relation | Quantity for 10000 M² Plinth Area | Rate (Rs.) | Amount (Rs.) |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1. | Cement | tonnes | 0 1925 A + 18.52 | 1943.52 | 2800 00 | 5441856.00 |
| 2. | Fine Sand | cu m | 0.08 A + 105.50 | 905.50 | 150 00 | 135825.00 |
| 3. | Coarse Sand | cu m | 0.2592 A — 80.94 | 2511.06 | 270.00 | 677986.20 |
| 4. | Coarse aggregate 20mm Nom size | cu m | 0.2728 A — 48.50 | 2679.50 | 355 00 | 951222 50 |
| 5. | Coarse aggregate 10mm Nom size | cu m | 0.1164 A — 20.74 | 1143 26 | 335.00 | 382992.10 |
| 6. | Coarse aggregate 40mm Nom size | cu m | 0 0151 A + 73.91 | 224.91 | 320.00 | 71971.20 |
| 7. | Brick ballast 25mm Nom size | cu m | 0.0426 A — 38.37 | 387.63 | 140.00 | 54268.20 |
| 8. | Timber for Formwork | cu m | 0.005 A + 11.19 | 61.19 | 10000.00 | 611900.00 |
| 9. | Timber for Joinery | cu m | 0.0024 A — 0.53 | 23.47 | 25000 00 | 586750.00 |
| 10. | Ballies | m | 0 5507 A + 797.5 | 6304.50 | 20.00 | 126090.00 |
| 11. | Bricks | % Nos. | 1.1829 A — 524.23 | 11304.77 | 110.00 | 1243524.70 |
| 12. | Deformed bars | tonne | 0 0479 A | 479.00 | 16000 00 | 7664000 00 |
| 13. | Door Shutters | sq m. | 0 0636 A — 17.07 | 618.93 | 800.00 | 495144.00 |
| 14. | Window Snutters | sq m. | 0.1117 A + 93.26 | 1210.26 | 250.00 | 302565.00 |
| 15. | Glass | sq. m. | 0.1407 A + 55.99 | 1462.99 | 140.00 | 204818.60 |
| 16. | Primer | Lit | 0.0256 A + 9.7 | 265.70 | 60.00 | 15942 00 |
| 17. | Paint | Lit | 0 0322 A + 7.24 | 329.24 | 120.00 | 39508.80 |
| 18. | Lime | qtls | 0.0754 A — 51.21 | 702.79 | 180.00 | 126502.20 |
| 19. | Surkhi | cu m | 0.0204 A — 18 39 | 185.61 | 250 00 | 46402.50 |
| 20. | Marble Chips | qtls | 0.1338 A — 48 52 | 1289.48 | 100.00 | 128948.00 |
| 21. | Marble POwder | cu m | 0.0012 A — 0 36 | 11.64 | 850.00 | 9894.00 |
| 22. | Mason | working days | 1 1314 A— 407.4 | 10907 | 100.00 | 1090700.00 |
| 23. | Carpenter | —do— | 0 7094 A + 444.09 | 7543 | 100.00 | 754300 00 |
| 24. | Glazier | —do— | 0 0122 A + 10 31 | 132 | 90.00 | 11880.00 |
| 25. | Painter | —do— | 0 0905 A + 37.26 | 942 | 90.00 | 84780.00 |
| 26. | Blacksmith | —do— | 0 479 A | 4790 | 100.00 | 479000.00 |
| 27. | Beldar | —do— | 6.095 A — 2024.37 | 58525.60 | 50.00 | 2926280.00 |

***FITTINGS (For doors)

Assuming the size of door shutter is $2m \times 1m$

Area of shutter $= 2m^2$

Totnl shutter area for the whole building $=618.93\ m^2$

No. of doors $\frac{618\ 93}{2} = 309\ 47$ say 310

Based on the above assumptions and computations :

| | | | | | |
|---|---|---|---|---|---|
| i) Hinges 100mm | Nos. | $3 \times 310$ (3 hinges per shutter) | 930 | 25.00 | 23250.00 |
| ii) Mortice Lock | Nos. | $1 \times 310$ (one Lock per shutter) | 310 | 240.00 | 74400.00 |
| iii) Tower bolt 250mm | Nos. | $1 \times 310$ (one bolt per shutter) | 310 | 30.00 | 9300.00 |

R. W. PIPE

100mm Total plinth area $= 10000\ m^2$

No. of Storeys $= 5$

Roof area $= \frac{10000}{5} = 2000\ m^2$

No. of R.W. Pipes $= \frac{2000}{40} = 50$ nos (one pipe serves $40m^2$ of roof area)

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| | Storey Height | | =3.1m | | | |
| | Length of each pipe | | =3 1×5=15.5+0.5=16 m approx | | | |
| | Total length of pipe | | =50×16=800m | 800.0 | 40.00 | 32000.00 |
| | A.C Shoe 100mm $\phi$ Nos. | | | 50 | 30.00 | 1500.00 |
| | A.C Head 100mm $\phi$ Nos. | | | 50 | 35.00 | 1750.00 |
| | A.C Bend 100mm $\phi$ Nos. | | | 50 | 25.00 | 1250.00 |
| | | | | | Total = | 24808501.00 |
| | Add for Scaffolding @ 0.25% | | | | = | 62021.25 |
| | | | | | | 24870522.25 |
| | Add for water charges and sundries @ 2% | | | | = | 497410.45 |
| | | | | | Total = | 25367932.70 |
| | Add contractor's profit and O H. @ 10% | | | | = | 2536793.30 |
| | | | | Total cost of Building | = | 27904726 00 |
| | | | | Plinth Area rate | = | 2790.05/m² |

Note :—The computation has been made with the rates (approx.) of the year 1996 at Roorkee

APPENDIX-C

## COMPUTATION OF BUILDING COST INDEX FOR THE YEAR 1996 W. R. T. 1993 AS BASE YEAR

| S. No. | Materials/Labour | Quantity | Unit | Year 1993 Rate (Rs ) | 1993 Amount (Rs.) | 1996 Rate (Rs ) | 1996 Amount (Rs.) |
|---|---|---|---|---|---|---|---|
| 1 | Cement | 1943.52 | tonnes | 2300 00 | 4470096.00 | 2800.00 | 5441856.00 |
| 2. | Sand | 3416 56 | m³ | 160 00 | 546649 60 | 250.00 | 854140.00 |
| 3. | Coarse aggregate | 4047.67 | m³ | 280.00 | 1133347.60 | 340.00 | 1376207.80 |
| 4. | TImber | 84 66 | m³ | 20000.00 | 1693200 00 | 25000.00 | 2116500 00 |
| 5. | Bricks | 11304.77 | %Nos. | 78 00 | 881772.06 | 110.00 | 1243524.70 |
| 6. | Steel | 479 00 | tonnes | 14000 00 | 6703000.00 | 16000 00 | 7664000.00 |
| 7. | Flush door shutter | 618 93 | m² | 630.00 | 389925.90 | 800 00 | 495144.00 |
| 8. | Steel window | 1210.26 | m² | 207-00 | 250523 82 | 250 00 | 302565.00 |
| 9 | Mason | 10907 | Days | 80.00 | 872560 00 | 100.00 | 1090700.00 |
| 10. | Carpenter | 7543 | Days | 80.00 | 603440 00 | 100 00 | 754300.00 |
| 11. | Blacksmith | 4790 | Days | 80.00 | 383200.00 | 100.00 | 479000.00 |
| 12. | Beldar | 58525 6 | Days | 40.00 | 2341024 00 | 50 00 | 2926280.00 |
| | | | | | 20271738.98 | | 24744217.50 |

cost Index $= \frac{24744217.50}{20271738.98} \times 100 = 122.06$ Say 122.0

NOTE : 1. Quantities have been comuted for a buildlng wi h 10,000m² plinth area.
2. Computation have been based only on major materials and labour.