Reprinted from THE INDIAN CONCRETE JOURNAL, October 1981 issue.

Rational approach for computation of building cost indices

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Cost index is an important tool used by engineers to carry out economic evaluation studies of engineering projects. It enables them to obtain a fairly reasonable estimate based on the past and current cost data and it is useful for a preliminary analysis. The cost index numbers for building materials and labour are important and any escalation in their cost is likely to upset the physical targets fixed in the plan expenditure. It is therefore necessary to evolve a system which could provide a realistic cost index to the building industry. Studies for the formulation of a building cost index have been carried out at the Central Building Research Institute. The paper suggests a method to calculate the cost index and separate data has been provided for residential and non-residential buildings, together with internal services.

It is necessary to have an estimate of the total cost of the building prior to the start of construction. This may be required for obtaining technical and administrative sanctions, planning and budgeting purposes, etc. The normal practice is to prepare detailed bills of quantities and price them with the help of a schedule of rates in force at the time. These schedules of rates are not revised every year, and to bring the estimated cost on par with the current year, it is multiplied with the cost index which may be defined as a number that gives an indication of increase or decrease in the cost of construction with respect to a certain base year.

Most engineering projects take a number of years to complete. The estimates for such projects are prepared subject to upward revision due to escalation of prices. Construction agencies are also interested to know the trend of variation in prices in order to make fair estimates of cost of construction. For the builders it is important to know such trends in advance to avert a situation where smooth running of the contract is jeopardised.

There are various categories of cost indices such as wholesale price index which reflects the trend in prices, consumer price index which is used for adjustment of claims for relief in wages, etc. These indices are prepared and maintained at the national level. But in the building industry there has not been much effort to prepare the cost indices. Neither is there a recognised method for evolving them. Various construction agencies have worked out their own systems which lack comparability because there is no uniformity in their approach. It has been observed that sometimes the same data is used for compilation of cost indices irrespective of the size and type of the building, type of construction, and specifications. In some organisations the cost index is based on the building portion only and the same is applied for services also (water supply and sanitary). This practice is not correct since there is non-uniform escalation of prices in materials required for building and those for services.

Studies have been carried out at the Central Building Research Institute to give the data in basic form for computation of building cost indices. These were based on a number of buildings with different plinth areas for a particular type of construction. Final bills of these buildings were analysed. These have been preferred to estimated quantities since there is always a difference between the two. Expressions were developed for a particular set of specifications which are most commonly adopted in the construction. The practice likely to be adopted for future construction projects was also kept in view while selecting these specifications. These specifications for residential and non-residential buildings respectively, are given in brief in *Appendices* 1 and 2.

The relations are given only for important materials and labour charges which make up the major part of building cost. In case of residential buildings, separate relations have been worked out for load bearing single and double-storeyed dwellings and four-storeyed framed construction, *Table* 1. For internal services, the data has been presented in a tabular form for double and four-storeyed construction, *Table* 2. For office buildings, only a single set of relations has been established irrespective of the number of storeys, *Table* 3. Study on internal services of office buildings is under progress.

The data can be made use of for computation of building cost index at any time and place. Requirement of major materials and labour can be computed with the help of these relations, for a particular plinth area range A, of the building. If there are different sizes of tenements in a project, the quantities may be worked out for a medium-size tenement. These quantities may be priced with the rates of the base year and also with the current market rates. The ratio of the total costs for both the years computed in terms of percentage increase or decrease will give the present cost index. An illustrative example is given in *Appendix* 3 where the cost index at Roorkee for the year 1980 has been worked out with respect to the base year 1977. Another example for office building is illustrated in *Appendix* 4. The cost index in this case has been computed based on materials and labour required for the building portion only. It can be seen that cost index for residential buildings is quite different than that for office buildings.

Conclusion

The method proposed in the paper is simple and can be used at any time and place because it is based on the primary inputs in terms of materials and labour. The information has been worked out for residential and office buildings based on a particular set of specifications. The study can be extended to other types of buildings such as educational buildings, health buildings, etc., and to other types of construction such as semi-pucca and kutcha buildings having different specifications.

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TABLE 1 Statistical relations for residential buildings (building portion only)

Serial no	Material/labour	Unit	Single-storey	Double-storey	Four-storey (framed)
1.	Bricks	'000	$2.26A + 66.8$	$2.15A + 63$	$-26.2+2.56A-0.0096A$
2.	Cement	tonne	$0.153A + 0.57$	$0.145A + 0.54$	$0.202A - 0.364$
3.	Mild steel	kg	$21.3A - 314.0$	$21.97A - 305$	$-1662+102.46A-0.40A^2$
4.	Sand	m^3	$0.47A - 7.0$	$0.376A - 5.6$	$0.397A - 0.38$
5.	Coarse aggregate	m^3	$0.321A + 1.29$	$0.253A + 0.57$	$0.369A - 0.31$
6.	Timber	m^3	$0.0232A + 0.23$	$0.0232A + 0.23$	$0.030A + 0.08$
7.	Mason	working day	$1.335A + 28.0$	$1.335A + 26.0$	$1.593A - 2.0$
8.	Carpenter	working day	$1.184A - 9.0$	$1.194A - 9.0$	$1.66A$
9.	Beldar	working day	$4.769A + 32.0$	$4.91A + 33.0$	$5.833A - 9.2$

Notes: (*i*) A is the plinth area of individual tenement in m^2

(*ii*) the relations are applicable for plinth areas varying from 30 to 300m^2 in case of single and double-storey buildings, and from 30 to 100m^2 for four-storey framed buildings

TABLE 2 Material and labour requirements for internal water supply and sanitary services for residential buildings

Serial no	Material/labour	Unit	Double-storeyed buildings				Four-storeyed buildings			
			type I janta	type II	type III	type IV	type V	type I	type II	type III	type IV
	Average plinth area	m^2	25.0	37.0	56.0	84.0	122.0	42.0	60.0	70.0	112.0
1.	Water closet*	nos	1	1	1	2	2	1	1	1	2
2.	Wash basin*	nos	nil	nil	1	1	2	nil	nil	1	2
3.	Sink*	nos	nil	nil	nil	1	1	nil	nil	1	1
4.	Sand cast iron pipe 100-mm	m	3.2	4.7	5.8	7.2	8.9	8.1	8.3	8.9	10.4
	75-mm	m	—	—	—	—	—	3.9	4.3	4.4	4.5
	50-mm	m	2.4	3.9	8.2	8.6	18.00	2.8	3.2	3.5	3.9
5.	Cement	tonne	0.21	0.28	0.37	0.37	0.51	0.19	0.24	0.25	0.33
6.	GI pipe 15-mm	m	11.0	11.0	14.0	18.7	38.5	22.4	26.2	30.0	57.0
	20-mm	m	—	10.4	18.7	21.5	40.0	17.6	23.4	25.0	41.0
7.	Pig lead	kg	8.7	13.6	23.7	26.2	47.0	22.3	23.3	25.3	29.6
8.	Reinforced concrete tank	nos.	0.5	0.5	0.5	0.5	1.0	1.0	1.0	1.0	1.0
9.	Fitter	working day	3.7	5.7	8.6	11.5	18.9	9.9	11.5	13.8	20.6
10.	Mason	working day	2.3	3.3	4.9	6.5	8.8	3.6	4.2	6.0	7.8
11.	Beldar	working day	8.1	11.4	16.3	20.6	30.4	17.6	22.0	24.0	34.6

**Note:* complete with all accessories and fittings

TABLE 3 Statistical relations for office buildings— building portion only

Serial no	Material/labour	Unit	Statistical relations
1.	Cement	tonne	$0.1925A + 18.52$
2.	Sand	m^3	$0.3392A + 24.56$
3.	Coarse aggregate	m^3	$0.4043A + 4.67$
4.	Timber	m^3	$0.0074A + 10.66$
5.	Bricks	'000	$1.1829A - 524.23$
6.	Deformed steel bars	tonne	$0.0479A$
7.	Flush door shutter	m^2	$0.0636A - 17.07$
8.	Steel window	m^2	$0.1117A + 93.26$
9.	Mason	working day	$1.1314A - 407.40$
10.	Carpenter	working day	$0.7094A + 449.09$
11.	Blacksmith	working day	$0.479A$
12.	Beldar	working day	$6.055A - 2024.37$

Notes: (*i*) A is the total plinth area of all the floors, m^2

(*ii*) the relations are applicable for plinth areas varying from 1600 to 26000m^2

(*iii*) the type of foundation considered is column footings

APPENDIX 1 Specifications for residential buildings

Serial no	*Element/item of work*	*Reference specifications for*	
		single and double-storey buildings	*four-storey building framed construction*
(i)	*Building portion*		
1.	Foundation	excavation in ordinary soil 1:5:10 (cement: fine sand: graded stone aggregate 40-mm nominal size) reinforced concrete in beds	excavation in ordinary soil reinforced concrete column footings with 1: 4: 8 concrete (cement : fine sand: graded stone aggregate 40-mm nominal size) in beds
		brickwork in 1: 6 cement-mortar using tradional bricks	brickwork in 1: 6 cement mortar using traditional bricks
		38-mm thick damp-proof coarse consisting of 1:2:4 concrete (cement: coarse sand: graded stone aggregate) with 1.7-kg/m² bitumen coating on top	sand filling in plinth over stone bedding, and under plain concrete beds.
2.	Frame	—	reinforced cement concrete frame, including finishing and plastering the exposed surface with 1: 3 cement-mortar of thickness not exceeding 6mm to give a smooth and even surface, including neeru finish
3.	Walling	brickwork in 1:6 cement mortar	brickwork in 1: 6 cement mortar
		half brickwork in 1:3 cement mortar with hoop iron reinforcement for partitions	reinforced concrete work for lintels, beams, chhajjas, including finishing and plastering the exposed surface with 1: 3 cement mortar of thickness not exceeding 6mm to give a smooth and even surface
		reinforced concrete work for lintels, beams, chajjas including finishing and plastering the exposed surface with 1: 3 cement mortar of thickness not exceeding 6mm to give a smooth and even surface	
4.	Floor	38-mm thick 1: 2: 4 concrete (cement: coarse sand: graded stone aggregate) laid over 1:5: 10 concrete (cement: fine sand: graded stone aggregate 40-mm nominal size) bed	38-mm thick 1: 2: 4 concrete (cement: coarse sand: graded stone aggregate) laid over 1: 5: 10 concrete (cement: fine sand: graded stone aggregate 40-mm nominal size) bed in ground floor and over reinforced concrete slab for upper floors
5.	Roof	reinforced concrete slab with lime concrete terrace with 1.7 kg/m² bitumen coating underneath	reinforced concrete slab with lime concrete terrace with 1.7kg/m² bitumen coating undermeath and top finished with 40-mm 1: 2: 4 concrete (cement: fine sand graded stone aggregate)
6.	Joinery	timber frames 100 × 75-mm for doors and windows fixed with flat iron holdfasts	timber frames 100 × 75-mm for doors and windows fixed with flat ironhold fasts
7.	Finishes	12-mm thick 1: 6 cement plaster on smooth side of walls and 20-mm thick 1: 6 cement plaster on rough side of walls	12-mm thick 1: 4 cement plaster on internal faces of walls and 20-mm thick 1: 3 cement plaster on external faces of walls
		20-mm thick cement plaster skirting and dado	internally white washed and externally colour washed
		internally white washed and externally colour washed	painting wood work and steel work with oil paint over a coat of primer
		painting wood work and steel work with oil paint over a coat of primer	
8.	Stairs	reinforced concrete stairs in double-storey construction	reinforced concrete stairs
9.	Fittings and fixtures	precast reinforced concrete shelves mild steel round bars in windows raised cooking platforms	precast reinforced concrete shelves mild steel round bars in windows timber cupboards raised cooking platforms

(*ii*) *Internal water supply and sanitary services*

		Specifications
1	Water closet	(*i*) for smaller tenements—one Indian type wc complete with all accessories (*ii*) for bigger tenements (where two wcs are provided)—one Indian type wc and one European type wc ; complete with all accessories.
2	Soil pipe/waste pipe/vent pipe	sand cast-iron pipe with lead caulked joints with paint of any colour over a cast of primer
3	Wash basin	white vitreous china wash basin 630 × 450-mm with single chromium plated brass pillar tap complete with all accessories
4	Kitchen sink	white glazed fire clay kitchen sink 600 × 450 × 250-mm complete with all accessories
5	Mirror	600 × 450-mm levelled edge mirror of superior glass with 6-mm thick asbestos sheet
6	Towel rail	chromium plated brass towel rail 750 × 20-mm
7	Water pipe	galvanised iron pipework with all fittings and finished with decorative paint
8	Bibcock/stop cock	brass bibcock/stop cock
9	Connection pipe	lead connection pipe with brass unions
10	Shower rose	chromium plated brass shower rose of 100-mm diameter with 15 or 20-mm inlet
11	Storage tank	reinforced concrete storage tank
		System of Services
12	Drainage system	for four-storey construction (*i*) 100-mm diameter soil pipe vented with 50-mm vent pipe (*ii*) 75-mm waste pipe without any vent pipe for double-storey construction 100-mm diameter soil pipe without any vent and 50-mm diameter waste pipe without any vent pipe
13	Overhead storage tank	for four-storey construction single tank of 270 lts. capacity for each tenement for double-storey construction one tank of 270 lts. capacity for two tenements in case of type I to type IV quarter; single tank for each tenement in case of type V quarter

Appendix 2 Specifications for office buildings

Serial no.	*Element/item of work*	*Reference specifications adopted for the study*
1	Foundation	excavation in ordinary soil reinforced column footings with 1: 5: 10 concrete (cement : fine sand: graded stone aggregate 40-mm nominal size) in beds sand filling in plinth under plain concrete beds brickwork in 1: 6 cement mortar using traditional bricks
2	Frame	reinforced concrete frame including finishing and plastering the exposed surface with 1:3 cement-mortar of thickness not exceeding 6-mm to give a smooth and even surface
3	Walling	brickwork in 1: 6 cement-mortar using traditional bricks half brickwork in 1 : 3 cement-mortar with hoop iron reinforcement for partitions reinforced concrete work for lintels, chhajjas, fins including finishing and plastering the exposed surface with 1: 3 cement mortar of thickness not exceeding 6-mm to give a smooth and even surface
4	Floor	terrazo (marble chips) flooring laid-in-situ, as follows: 100-mm thick 1: 5: 10 concrete (cement: fine sand: graded stone aggregate 40-mm nominal size) subgrade for ground floor and 50-mm thick cushioning layer of lime concrete using brick aggregate of 25-mm nominal size and 50 percent mortar comprising of 1 lime: 2 surkhi on reinforced slab for upper floors 40-mm thick marble chips flooring, rubbed and polished to granolithic finish (machine grinding) under layer 31-mm thick 1: 2: 4 concrete (cement:coarse sand: graded stone aggregate 10-mm nominal size) and top layer 9-mm thick with marble chips laid in cement and marble powder 3: 1 mix by weight in proportion of 4:7 (cement marble powder mix: marble chips) by volume 21-mm thick marble chips skirting rubbed and polished to granolithic finish underlayer 15-mm thick 1: 3 cement plaster and top layer 6-mm thick with marble chips laid in cement and marble powder 3: 1 mix by weight in proportion of 4: 7 (cement marble powder mix: marble chips) by volume
5	Structural floor/roof	reinforced cement concrete slab including finishing and plastering the exposed surface with 1:3 cement mortar of thickness not exceeding 6-mm to give a smooth and even surface
6	Joinery	doors—timber frames 100 × 60-mm for doors with 40 × 3-mm flat iron holdfast 400-mm long and embedded in 300 × 100 × 150-mm block of plain 1: 3: 6 (cement: coarse sand: graded stone aggregate 20-mm nominal size) concrete 35-mm thick flush door shutters, non-decorative type windows — steel glazed windows of standard rolled steel sections
7	Plastering	12-mm thick 1:6 cement plaster on smooth face of brick walls 20-mm thick 1:6 cement plaster on rough face of brick walls
8	Finishes	painting on doors and windows over a coat of primer whitewash or colour wash both internally and externally

Appendix 3 Computation of building cost index for residential buildings at Roorkee for the year 1980 with respect to the year 1977 taken as 100

Serial no	Material/labour	Quantity	Unit	Cost in the year 1977 rate	Cost in the year 1977 amount		Cost in the year 1980 rate	Cost in the year 1980 amount	
				BUILDING PORTION					
1.	Bricks	18.34	'000	175.00	3209.50		250.00	4585.00	
2.	Cement	8.66	tonnes	365.00	3160.20		500.00	4330.00	
3.	Mild steel	925	kg.	2.00	1850.00		4.20	3885.00	
4.	Sand	15.5	m^3	28.00	434.00		32.00	496.00	
5.	Coarse aggregate	14.74	m^3	41.00	604.34		70.00	1031.80	
6.	Timber	1.53	m^3	2000.00	3060.00		2100.00	3213.00	
7.	Mason	102.00	working day	13.00	1326.00	16477.74	16.00	1632.00	22564.80
8.	Carpenter	58.00	working day	13.00	754.00		16.00	928.00	
9.	Beldar	308.00	working day	6.75	2079.00		8.00	2464.00	
				SERVICES					
10.	Water closet	1	no.	200.00	200.00		350.00	350.00	
11.	Wash basin	1	no.	150.00	150.00		250.00	250.00	
12.	Sink	nil	no.	nil	nil		nil	nil	
13.	Sand cast-iron pipe 100-mm	5.8	m	20.00	116.00		32.00	185.60	
	50-mm	8.2	m	12.00	98.40		20.00	164.00	
14.	Cement	0.37	tonne	365.00	135.05		500.00	185.00	
15.	Galvanised Pipe 15mm	14.00	m	7.00	98.00		15.00	210.00	
	20mm	18.7	m	9.00	168.30		18.00	336.60	
16.	Pig lead	23.7	kg.	9.00	213.30	1614.58	12.00	284.40	2512.00
17.	Reinforced concrete tank	0.50	no.	300.00	150.00		400.00	200.00	
18.	Fitter	8.6	working day	13.00	111.80		16.00	137.60	
19.	Mason	4.9	working day	13.00	63.70		16.00	78.50	
20.	Beldar	16.3	working day	6.75	110.03		8.00	130.40	
	Total =				18092.32			25076.80	

Cost index (taking into account the cost of internal water supply and sanitary services also) $= \frac{25076.80}{18092.32} \times 100 = 138.60$

Cost index (internal services only) $= \frac{2512.00}{1614.58} \times 100 = 155.58$

Cost index (building portion only) $= \frac{22564.80}{16477.74} \times 100 = 136.94$

Note:- quantities have been worked out with the help of *Tables* 1 and 2 for type III tenement with 56m² plinth area (double-storeyed construction).
substituting A with 56m²

Appendix 4 Computation of building cost index for office buildings at Roorkee for the year 1980 with respect to year 1977 taken as 100

Serial no	Material/labour	Quantity	Unit	1977 rate	1977 amount	1980 rate	1980 amount
1.	Cement	1943.52	tonnes	365.00	709384.80	500.00	971760.00
2.	Sand	3416.56	m^3	28.00	95663.68	32.00	109329.92
3.	Coarse aggregate	4047.67	m^3	41.00	165954.47	70.00	283336.90
4.	Timber	84.66	m^3	2000.00	169320.00	2100.00	177786.00
5.	Bricks	1130.477	'000	175.00	197833.47	250.00	282619.25
6.	Steel	479.00	tonnes	2200.00	1053800.00	4500.00	2155500.00
7.	Flush door shutter	618.93	m^3	115.00	71176.95	170.00	105218.10
8.	Steel window	1210.26	m^3	90.00	108923.40	200.00	242052.02
9.	Mason	10907.0	days	13.00	141791.00	16.00	174512.00
10.	Carpenter	7543	days	13.00	98059.00	16.00	120688.00
11.	Blacksmith	4790	days	13.00	62270.00	14.00	67060.00
12.	Beldar	58525.6	days	6.75	395047.80	8.00	468204.80
				Total =	3269223.50		5158066.90

Cost index $= \frac{5158066.90}{3269223.50} \times 100 = 157.78$, say 158

Note: quantities have been computed with the help of *Table* 3 for a building with 1000m² plinth area

Printed and published by Ramesh R. Verma on behalf of The Concrete Association of India, a Division of The Associated Cement Companies Limited, and printed at the TATA PRESS Limited, Bombay-400 025 and published at 'Cement House', 121, Maharshi Karve Road, Bombay,
Editor B. T. Unwala, BE FIE (Ind.) FI Struct E (Lond.).