Report on Benchmarking for Cost Estimation of Metro Rail Projects

Government of India
M/o Housing & Urban Affairs
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Index

1. Introduction:

1.1 High capacity rail based mass transit system popularly called Metro, are rapidly being accepted across the country. Following the success of the Delhi Metro, many cities have implemented metro rail systems. Metro rail system is already operational in the cities of Delhi and NCR, Bengaluru, Chennai, Hyderabad, Jaipur, Kochi, Kolkata, Lucknow and Mumbai. Metro rail is also under construction in these cities and some other cities like Ahmedabad, Nagpur, Pune, Bhopal and Indore. Cities like Patna, Kanpur, Agra, Thiruvananthapuram, Kozhikode, Guwahati, Chandigarh, Surat, Ranchi etc. are also aspiring to have metro rail system.

1.2 Most of the metro rail projects have been financed by the central government in partnership with the state governments, while some have been funded by the state governments either on their own or with private partnership. In addition, external loan has also been taken under sovereign guarantee. Metro rail projects provide high capacity public transit and are capital intensive.

1.3 With a view to systematically augment the metro rail transport in the country, the Ministry of Housing and Urban Affairs has issued the Metro Rail Policy,2017. The policy bridges the much needed gap for ascertaining and enhancing the feasibility of metro rail projects from economic, social and environmental perspective. This aims to focus on systematic planning and implementation of metro rail systems and act as a guide to state governments for preparing comprehensive proposals for metro rail projects.

1.4. Ministry of Housing and Urban Affairs has formulated standard specification of various metro components like Rolling Stock, Signalling, Electrical and Electromechanical components and Standards for civil structure to promote 'Make in India' and reduction in cost. Implementation of Public Procurement (Preference to Make in India) Order, 2017 issued by Department of Industrial Policy and Promotion and adoption of minimum local content fixed by Ministry of Housing and Urban Affairs for procurement of metro components would also encourage indigenisation and reduction in cost.

1.5 In order to ensure uniformity in cost estimation of metro projects, need was felt to devise a costing framework and fix benchmark for costing of metro components.

2. Background:

2.1 Niti Aayog, in its meeting held on 6th July 2018 under the chairmanship of Dr. V.K. Saraswat, Member, NITI Aayog, advised Ministry of Housing and Urban Affairs, to formulate a costing framework document for metro rail projects. Accordingly, a Committee of Director/Deputy Secretary level officers from Ministry of Housing & Urban Affairs and NITI Aayog was constituted vide O.M. No. K-14011/23/2016-MRTS-Coord dated 4th September, 2018 to formulate benchmark for costing of metro rail projects. Two officers were nominated by NITI Aayog, vide O.M. No.7/16/2018-TPT dated 4th October, 2018. NITI Aayog also directed to nominate one officer from DMRC who in turn nominated two officers dealing with cost estimation vide letter no. DMRC/CS/Benchmark Costing/2018 dated 8th October, 2018.

3. Components of metro project cost:

The following cost components have been taken in the Detailed Project Reports(DPR) of sanctioned metro projects.

SN	Description
1	Alignment & Formation
1.1	Elevated section (viaduct) including in station portion and elevated ramp
1.2	Underground Section by Tunnel Boring Machine (TBM)
1.3	Underground section by cut & cover (for underground ramp)
2	Station Buildings (Civil, Electrical and Electromechanical equipment)
2.1	Elevated Station (Civil including finishes) excluding viaduct in station portion
2.2	Elevated Station (E&M including lift and escalator)
2.3	Underground Station (civil including finishes)
2.4	Underground Station (E&M including, ECS,TVS, lift and escalator)
3	Permanent Way
3.1	Ballast less track
3.2	Ballasted track
4	Traction & power supply
4.1	Elevated section
4.2	Underground section
5	Signalling and Telecom
5.1	Signalling
5.2	Telecommunication
6	Automatic Fare Collection(AFC)
7	Platform Screen Doors(PSD)
8	Miscellaneous Utilities
8.1	Civil
8.2	E&M
9	Multimodal Integration
10	Depot (Civil, Electrical and Electromechanical equipment)
10.1	Civil
10.2	E&M
11	Administrative Building and Operation and Control Centre
11.1	Civil
11.2	E&M
12	Staff Quarters
12.1	Civil
12.2	E&M
13	Rolling stock
14	Security

14.1	Civil
14.2	E&M
15	Land
16	Resettlement and Rehabilitation (R&R)
17	General charges
18	Contingency
19	Taxes
20	Escalation in cost during construction

3.1 Alignment and Formation

(a) Elevated section (viaduct)

Viaduct is a long elevated roadway/railway consisting of a series of short spans supported on piers. Superstructure is the part of structure above ground level that receives the loads, transfers to the substructure safely through bearings and serves the purpose of the structure's intended use. A pier is a large dimensional column which supports the superstructure and transfers large super-imposed loads to the foundation. Substructure supports the superstructure and transmits the loads to the foundation via piers. Cost of viaduct includes superstructure, substructure, pier, pier cap and foundation etc.

(b) Underground section by Tunnel Boring Machine (TBM) excluding station box

Tunnel is an underground passageway of circular cross section, bored through the surrounding soil/rock and enclosed except at each end for entrance and exit. Tunnel Boring Machine (TBM) is used to excavate tunnels with a circular cross section through a variety of soil and rock strata. It can bore through hard rock, sand, and almost anything in between. Tunnel boring machines are used as an alternative to drilling and blasting (D&B) methods in rock and conventional 'hand mining' in soil. TBMs have the advantages of limiting the disturbance to the surrounding ground and producing a smooth tunnel wall. This significantly reduces the cost of lining the tunnel, and makes them suitable to use in heavily urbanized areas. The major disadvantage is the upfront cost. TBMs are expensive to construct, and can be difficult to transport. However, as modern tunnels become longer, the cost of tunnel boring machines versus drill and blast is actually less. This is because tunneling with TBMs is much more efficient and results in a shorter completion time. The longer the tunnel, the less the relative cost of tunnel boring machines versus drill and blast methods. Cross Passage is the connecting passage provided between the two running tunnels and provided for emergency and maintenance access.

The cost of tunneling may depend on length of run, depth from ground level, condition of soil (normal, sandy, rocky etc.) and easy in working etc. which may vary from place to place.

(c) Underground section by Cut and Cover:

Normally, underground ramp is constructed by cut and cover method. The rate varies from place to place depending geological/site conditions. Quantum of work involved for this is very small and is clubbed with TBM/ underground station work for tendering.

3.2 Station Buildings:

(a) Elevated Station excluding viaduct (Civil work):

Station is the main activity centre of the metro system which holds major share in total project cost. Electrical and mechanical items, lift and escalator, auxiliary substation, DG set, Automatic Fare Collection System (AFC), Platform Screen Doors (PSD), Telecommunication system etc. are installed at stations. It is seen that three types of elevated stations viz. type A, B and C have been considered in the cost estimates in the DPRs. The requirement of civil structure for three types of elevated station is more or less same. The difference is in the requirement of signalling, point and crossing. The size of the platform (length x width) also varies from metro to metro. Station layout, simple Entry/Exit and station interior and inter station distance become extremely important from cost point of view. The average inter station distance in Indian metro system varies from 1 km to about 1.45 km. Station structure is generally of two level viz. concourse level and platform level. The civil cost of station can be reduced by space optimisation and value engineering. Station rooftop is also utilised for installation of solar panel.

(b) Elevated station (E&M work including lift and escalator)

Electrical and Mechanical System at Elevated Stations are broadly divided into three sub-systems namely, Electrical System, Fire Alarm, Detection & suppression System and VAC System. The components of electrical system at elevated stations are Low Voltage(LV) panels, distribution boards, cables and cable containments, wiring and conduiting, lighting systems, earthing system and UPS etc. DG Sets are used to supply power to Essential Loads in case of failure of Power Supply at the station. In addition, Lifts and escalators are also provided at each stations for convenience of passengers.

It is observed that cost of lifts and escalators are separately provisioned in DPRs of some projects. Generally, four lifts and four escalators are provided at each elevated station.

(c) Underground station (Civil work):

The requirement of electrical and electromechanical equipment of underground station is different than those for elevated station. Additional space is required for installation of Environmental Control System (ECS) and Tunnel Ventilation System (TVS). Moreover, electrical load of underground station is about ten times more than that required for an elevated station. In order to accommodate these equipment and systems, the length of station box for a six coach platform length of 135m to 140 m is taken as 240 m to 265 m. Civil cost of an underground station can be reduced by reducing station box size. After discussion with metro officials, it is concluded that there is ample scope of reduction in station box length by way of space optimisation and relocation of equipment and service rooms. Chennai metro has constructed one underground station of six coach platform length in station box of 150 m length by optimising the utility and service rooms, relocating the machinery and plant, changing orientation of TVS etc. Official of other metros were also in agreement with the idea of reducing the station box length to about 200 m to 190 m or even less. By doing so, there will be considerable reduction in civil cost of underground station due to reduction cost of earth work, concreting and diaphragm wall. With the reduction in length of station box, there will be corresponding increase in tunnel length. However, there should be overall reduction in cost as cost per meter of tunnelling is less than cost per meter of station box.

(d) Underground station (E&M work including ECS, TVS, Lift and Escalator):

In addition to Electrical and Mechanical System required for elevated stations, plants and machineries like water treatment plant, sewage and seepage system, station ventilation and fume extraction system, Tunnel ventilation system etc. are also required at underground system. Moreover, the electrical load for Underground Station is about ten times greater than that for elevated station. Requirement of lifts and escalators at underground stations are also more. Obviously, the unit cost of E&M items for underground station would be much more than that required for elevated station.

3.3 Permanent way:

The permanent way is the rail track intended to carry the railway trains. As we know, ballasted track and non-ballasted or ballast less track are two typical kind of railway track. Ballasted track is a type of traditional railway tracks. Ballasted track is commonly composed of steel rail, sleepers, fasteners and ballast bed.

Ballast less track, is the railway track whose bed is composed of concrete and bituminous mixture, etc. and is made up of steel rail, railway fasteners and concrete slab.

Ballast less track is laid on the mainline and ballasted track is used in the depot. However, in workshop and maintenance area in the depot, the track is ballast less.

The construction of ballast less/ballasted track is done under works contract. Some metro companies have procured rail, turnouts, and fasteners separately and installation, testing and commissioning of ballast less/ballasted track done under separate works contract. The metro engineers are of the view that the cost of P Way becomes lesser if the rail, fasteners and turnouts are procured directly from the manufactures.

3.4 Traction and Power supply:

Two types of Traction systems are being used for Metro systems in India viz.25 kv AC Overhead Catenary System(OCS) and 750 V DC Third Rail system. Selection of type of Traction system is decided by Metro based on their ridership/future traffic projection/cost etc.

(i) 25 kv AC OCS Traction (ROCS/FOCS): In this system, Flexible Overhead Catenary System (FOCS) is used for Elevated & at Grade section while Rigid Overhead Catenary System (ROCS) accomodatable to tunnel bore diameter is used in underground section.

(ii) 750 V DC Third Rail Traction: In this system, 'Third Rail' is used for Traction for elevated, at grade and underground section.

The traction and power supply consists of five main components, traction (OCS and Third Rail), Internal Power Distribution System, Receiving Sub Station(RSS), extra high voltage cabling from source to RSS and Supervisory Control and Data Acquisition System (SCADA). RSS also houses Traction Sub Station (TSS) in OCS system whereas in Third Rail system, TSSs are installed at stations/bay side because of low voltage/ high current. Metro systems have their own internal high voltage cable distribution network, generally at 33 kv. The purpose of such cable distribution network is to feed all auxiliary substations at each station as well as to feed traction substations in case of DC traction system. Generally, 33 kv internal network is used in metro system. In case of 25 kv AC traction systems, the traction and auxiliary networks get separated at 25 kv and 33 kv voltage level. However, in case of DC traction system, the same type of cable distribution system feeds the traction substations also.

Auxiliary substation in both the traction systems is installed at stations itself. The cost of 25 kv OCS is different for elevated and underground portion where as cost of third rail traction is same for both elevated and underground. The cost of power supply for both OCS and third rail is different for elevated and underground as installed load for underground station is much more (about ten times). The required load for a six coach elevated station is about 300 kva whereas for an underground station it is about 3,000 kva. Some stations may require even more electric load due to additional commercial area.

The cost of extra high voltage cabling from Grid to RSS, which is of considerable amount, depends upon the distance of RSS from Grid and vary from city to city. Moreover, no separate provision of costing for traction and power supply requirement for depot has been made in the DPRs and probably the cost of depot portion is also subsumed in the cost of mainline.

Bengaluru, Kochi and Ahmedabad metro use 750 V DC third rail traction system whereas other metro use 25 kv AC OCS system. The cost of 750 V DC third rail traction and power supply system is more than that of 25 kv OCS. Four 33kV cable circuits, two for auxiliary and two for traction networks is used by

Bengaluru metro. Kochi and Ahmedabad metro use two cable 33 kv circuit common for both auxiliary and traction system.

3.5 Signalling and Telecommunication

(a) Signalling

Standardization of broad parameters of signalling systems for metro railways in India issued by Ministry of Housing and Urban Affairs in April, 2017, stipulates that 'Continuous Automatic Train Control system of working based on communication based train control system (CBTC) shall be adopted on the metro railway for movement of trains between stations'. CBTC system shall be based on moving block. Depot area may be equipped with similar CBTC system or a suitable interlocking system as per requirement of the metro railway. Wireless communication system shall be used for communication between the wayside and train borne CBTC system. CBTC system shall be capable of providing bidirectional movement.

"Continuous Automatic Train Control system" means an automatic system of controlling and monitoring train movements continuously by means of sub-systems, namely, Automatic Train Protection System, Automatic Train Operation system and Automatic Train Supervision System.

Components of Signalling system are way side and stations equipment, On board equipment, Depot equipment and Operation Control Centre(OCC)/Back up Control Centre (BCC). The cost depends upon number and length of line in depot under signalling, number of cabs in which the on board equipment are installed, requirement of equipment in way side and stations and equipment in OCC/BCC. Cost estimates of the sanctioned DPRs indicate that the cost of signalling and telecommunication combined per route kilometre (RKM) of main line has been taken and costs of other centres like depot, on board equipment and OCC/BCC are subsumed in the mainline itself.

After detailed analysis, the committee, is of the view that the cost of signalling and telecom should be taken separately for cost estimation. Signalling cost should be bifurcated into three parts namely cost for mainline and OCC/BCC per RKM, cost of depot equipment per TKM of depot and cost of On-Board equipment per train. Here, it is worth mentioning that the on board equipment are installed in the front and rear cabs of the train and hence cost per train is independent of number of coaches in the train.

(b) Telecommunication:

The Telecommunication system acts as the communication backbone for Signalling systems and other systems such as SCADA, AFC etc. and provides Telecommunication services to meet operational and administrative requirements of metro network. The components of telecommunication system of metro rail are as below:

- Fibre Optic System - Main Telecommunication Bearer
- Telephone Exchange
- Mobile Radio Communication
- Passenger Announcement System
- Passenger Information Display system
- Centralised Clock system
- Close Circuit Television System
- Network monitoring and management, etc.

The cost of signalling and telecommunication combined is taken per route kilometre (RKM) of main line in the DPRs and costs of other centres are subsumed in the mainline itself. Telecom equipment are installed at stations, depot and OCC/BCC. Accordingly, the cost of telecom is distributed in two parts, viz. cost per station and per depot. Cost of telecom components in OCC/BCC is proportioned in cost of stations and depots.

3.6 Automatic Fare Collection(AFC) System:

Metro Rail Systems handle large number of passengers. Ticket issue and fare collection play a vital role in the efficient and proper operation of the system. To achieve this objective, ticketing system shall be simple, easy to use/operate and maintain, easy on accounting facilities, capable of issuing single/multiple journey tickets, amenable for quick fare changes and require overall lesser manpower. In view of above, computer based automatic fare collection system is used in metro system. Automated Fare collection is a smart payment method for intelligent public transport systems using the pre-paid cards or tickets to pass through the electronic systems or gates to allow commuters to access to and from the various transportation modes such as Railways, Buses, Metro, Taxi, Parking etc. Store Value Smart Cards and contactless smart tokens are used for fare collection. The components of AFC system are Fare media, Devices to read/write media gates, station computers and AFC Network, Back office systems and Central clearing house etc.

Some metro companies like Kochi and Nagpur have implemented AFC system on PPP basis. AFC system in Kochi metro is already operational in which the CAPEX of AFC system has been borne by the concessionaire. The Kochi One card is compatible to be used in non transport payments also. Maha-Metro has also appointed concessionaire for installation of AFC for Nagpur and Pune metro on PPP basis. Other metro projects may also explore installation and maintenance of AFC system on PPP basis.

3.7 Platform Screen Door (PSD):

Platform screen door separates the platform from the train. PSDs act as a physical barrier preventing people or objects from falling or trespassing onto the tracks. Provision for this item has been made in some of the projects. Cost of platform screen doors is taken as per station basis.

3.8 Shifting of Miscellaneous Utilities:

The utility items like drainage, sewage, electric poles, cables, water pipelines etc. are required to be shifted/relocated from the metro alignment and station location. The requirement of shifting of these utilities vary from place to place and the cost of shifting per RKM is provisioned in the metro cost estimates. Cost towards shifting of utilities can be better estimated after detailed survey and stakeholders' consultation.

3.9 Multimodal integration and Last Mile Connectivity:

As per metro rail policy, 2017, provision for multimodal integration and last mile connectivity in the DPR is mandatory. In order to connect the people to the metro rail system, proper integration with other modes of transport, first and last mile connectivity, pedestrian pathway, non-motorised transport etc. are essential requirement and these facilities should be planned and detailed at the time of preparation of DPR itself. Cost of multimodal integration and last mile connectivity should be estimated on per station basis.

3.10 Depot:

Preventive and corrective maintenance of metro coaches are done in the depot. Infrastructure for stabling, cleaning and maintenance of metro trains/coaches is created inside depot. In addition to civil and E&M items, P Way, traction and power supply, signalling and telecom items are also installed in depot. However, provision of cost for Civil and E&M works only are made in most of the DPRs and cost of other components are subsumed in the mainline cost. Provision of costing of above components should be made separately for depots.

3.11 Admin Building and Operation and Control Centre (OCC):

Separate provision for civil and E&M works for admin building and OCC is made in the DPRs on lump sum basis. For economy of cost, admin building and OCC should be constructed inside depot. This will also enable better management and monitoring of the system.

3.12 Staff Quarters:

Provision for civil and E&M cost for construction of staff quarters for operation and maintenance personnel is made in DPRs of some metro projects.

3.13 Rolling Stock:

The term rolling stock in rail transport refers to any vehicles that move on a railway. It usually includes both powered and unpowered vehicles, for example locomotives, railroad cars, coaches, and wagons. Rolling stock for metro rail system usually refers to both powered and unpowered coaches used for transportation of passengers. The broad parameters of metro rolling stock have been standardised and 75% of the tendered quantity has to be manufactured in India. This will lead to indigenisation and reduction in cost.

3.14 Security:

The capital expenditure for security at station is separately provisioned. Cost towards barricading the platform entrance, baggage scanner, metal detector, frisking booths etc. is provisioned under Civil and E&M portions on per RKM basis in some DPRs and on lump sum basis in some DPRs. Since, the requirement of security is at the station, it would be proper to make provision for security items on per station basis. Cost of close circuit television is included in cost of telecommunication system.

3.15 Escalation in Cost:

Cost of the components does not remain constant and it normally increases due to inflation. Thus, provision for escalation in cost during construction period is made in the cost estimate. The methodology adopted for arriving at the escalation in cost is not elaborated in the DPR. It is also observed that the escalation in cost does not commensurate with the % annual escalation considered and the escalation period. Moreover, escalation period taken in the DPR is different from scheduled completion period of the project.

4. Proposed benchmark for costing of metro components:

After detailed examination and consultation, the committee proposes the following benchmark for costing of metro components for cost estimation of metro projects.

4.1 Six coach platform metro system

Unit cost excluding taxes and duties at January, 2019 price level

(Rs. in crore)

SN	Description	Unit	Unit Cost	Remarks
1	**Alignment & Formation**			
1.1	Elevated section (viaduct) including in station portion and elevated ramp	RKM	37	Separate provision should be made for special spans requiring crossing of river and lake.
1.2	Underground Section by Tunnel Boring Machine (TBM) and Cut & Cover	RKM	125	Length of station box(es) of underground station(s) should be excluded while calculating the length of UG section by TBM. Generally, underground ramp is constructed by cut and cover which is of very small length and is clubbed with TBM/station work.

2	**Station Buildings**			
2.1	Elevated Station (Civil including finishes) excluding viaduct in station portion	Per Station	26	
2.2	Elevated Station (E&M including lift and escalator)	Per Station	8	
2.3	Underground Station (civil including finishes)	Per Station	125	
2.4	Underground Station (E&M including, ECS,TVS, lift and escalator)	Per Station	50	
3	**Permanent Way**			
3.1	Ballast less track	RKM	6.6	
3.2	Ballasted track for Depot, At Grade section	TKM	3.9	
4	**Traction & power supply**			
4.1	**25 kv Overhead Catenary System (OCS)**			
4.11	Elevated section	RKM	7.5	
4.12	Underground section	RKM	11.5	
4.13	Depot	TKM	2	Provision for Catenary Maintenance Vehicle may be done separately
4.14	RSS cum TSS	Each	45	Separate provision for cost of 132/220/400 kv cabling from Grid to RSS cum TSS (if length is more than 0.5 km) may be made
4.2	**750 v DC Third Rail**			
4.21	Elevated section	RKM	11	
4.22	Underground section	RKM	12.5	
4.23	Depot	TKM	3	
4.24	RSS	Each	25	Separate provision for cost of 132/220/400 kv cabling from Grid to RSS (if length is more than 0.5 km) may be made
5	**Signalling and Telecom**			
5.1	**Signalling**			
5.11	Main line including OCC/BCC	RKM	4.4	
5.12	Depot including DCC	TKM	3.2	
5.13	On Board Equipment	Per Train	1.7	Cost of on-board equipment per train for three coach, six coach and nine coach train will be same as these are installed in front and rear cabs of the train only
5.2	**Telecommunication**			
5.21	Station	Per Station	4.5	Includes proportional cost of OCC/BCC
5.22	Depot	Per Depot	3.5	

6	**Automatic Fare Collection(AFC) system**	Per Station	3.5	
7	**Platform Screen Doors(PSD)**	Per Station	3	
8	**Shifting of Miscellaneous Utilities**			
8.1	Civil	RKM	6	The requirement of utility shifting varies from place to place. Hence no separate benchmarking for civil and E&M is proposed. However, based upon the experience of different metro companies, amount upto Rs. 6 crore per RKM may be provisioned for both Civil and E&M utility shifting combined.
8.2	E&M	RKM		
9	**Multimodal Integration and Last mile connectivity**	Per Station	3	The requirement for this item may vary from city to city. The amount of Rs. 3 crore per station has been provisioned as upper limit. The items and scope of work covered under this head should be detailed. This money shall not be utilised for other work. No re-appropriation to other component shall be done by implementing agency.
10	**Depot, Admin Building and Operation and Control Centre**			
10.1	Civil	Per Depot	105	This includes civil cost of admin building, OCC etc. and cost of machinery and plants for the main depot and workshop. For additional depot(s), if required, for other corridors, extension of existing corridor, provision of cost for bare minimum requirement should be made.
10.2	E&M and M&P	Per Depot	65	
10.3	Others	--	--	Cost of P. way, Traction and Power supply, Signalling and Telecom in depot mentioned against respective component
11	**Staff Quarters**			
11.1	Civil	--	--	Requirement of staff quarter varies from place to place. It is observed that no provision for the staff Quarter has been made in some of the DPRs. No benchmarking is proposed. However, if need for quarter is felt, provision may be made with proper justification
11.2	E&M	--	--	
12	**Rolling Stock**	Per Coach	8	
13	**Security**	Per Station	0.37	Cost towards barricading the platform entrance, baggage scanner, metal detector, frisking booths etc.

4.2 Three coach and nine coach platform length metro system:

As per standard specification of metro rolling stock issued by Ministry of Housing and Urban Affairs, the composition (no of coaches) of metro train would be in the multiple of three, ie., trains can have either 3 coach or 6 coach or 9 coach. Accordingly, the metro system would be of either three coach platform length or six coach platform length or nine coach platform length.

Unit cost of all items mentioned in para 4.1 above except for items under SN. 2.1 to 2.4,4.11,4.12,4.14, 4.21,4.22,4.24, 5.21 and 7 would be same for three coach and nine coach platform length systems also. Unit cost of items under SN. 2.1 to 2.4,4.11,4.12,4.14,4.21,4.22,4.24, 5.21 and 7 for three coach platform length system would normally be lower than the benchmark cost for six coach platform system. Whereas those for nine coach platform length system would normally be higher.

No benchmark is proposed for these items for three coach and nine coach platform length system due to non availability of sufficient data. Three coach platform length underground metro system and nine coach platform length metro system (both elevated and underground) at present not available in India. The proponent may estimate unit cost of these items after detailed analysis and suitable reference may be made accordingly.

5. **Land, Resettlement and Rehabilitation:**

Cost towards these items at prevailing rates and local requirements are provisioned in the cost estimate. No benchmarking can be done. As per extant guidelines, this cost is borne State Government.

6. Escalation in cost during construction:

Procedure for calculation of escalation during construction period

Annual escalation @ 5% as stipulated in minutes of meeting of Public Investment Board (PIB) on Pune Metro Rail Project circulated vide Department of Expenditure OM No. 30(37)/PF-II/2013, Dated 24th October, 2016 is taken for calculation of escalation in cost during construction period. The cost of the project at base price level is allocated for year wise expenditure during the construction period. The year wise expenditure should be derived from the PERT/Time Line chart prepared for the implementation of the project. Formula for calculation of year wise escalation factor, escalation in cost and completion cost during the construction period is proposed as below:

Year	Estimated Expenditure during the year at Price Level of Base Year	Escalation Factor (%)	Completion cost	Escalation in cost
1	P1	(1+0.05)**0+0.05/2=1.025	C1=P1*1.025	E1=C1-P1
2	P2	(1+0.05)**1+0.05/2=1.075	C2=P2*1.075	E2=C2-P2
3	P3	(1+0.05)**2+0.05/2=1.1275	C3=P3*1.1275	E3=C3-P3
4	P4	(1+0.05)**3+0.05/2=1.1826	C4=P4*1.1826	E4=C4-P4
5	P5	(1+0.05)**4+0.05/2=1.2405	C5=P5*1.2405	E5=C5-P5
Total	P=P1+P2+ P3+P4+P5		C=C1+C2+ C3+C4+C5	E=E1+E2+ E3+E4+E5

7. **General Charges:**

General Charges @ 5% as stipulated in minutes of meeting of Public Investment Board (PIB) on Pune Metro Rail Project circulated vide Department of Expenditure(DoE) OM No. 30(37)/PF-II/2013, Dated 24th October, 2016 is provisioned.

8. **Contingency:**

Provision for unforeseen contingencies is made @ 3 % of the basic estimated cost.

9. The unit cost mentioned in para 7 above is indicative for cost estimation of metro project proposals and should not be taken as reference or base rate for finalisation of tenders.

10. Cost of construction of civil structures may vary depending upon geographical and geological conditions.

11. Requirement of additional items, if found necessary, may be provisioned separately with proper justification.

12. Stations contribute about 35 % to 40 % of the total cost (excluding rolling stock) of elevated metro system and about 55% to 60 % in the underground system. Thus average inter station distance becomes important factor in controlling the cost of fixed installation. Indian metros have adopted average interstation distance varying from 1 km to 1.45 km. There are metro companies across the world which have adopted higher inter-station distance and stations are provided with multiple entry/exit at far distance from the station area. Stations are connected with sub-ways or sky-walk/foot over bridge to increase the catchment. By doing so, construction cost is reduced as number of stations would be less. Reduction in overall cost of metro system (excluding rolling stock) vis a vis interstation distance, based upon the benchmark cost is shown below:

	Approx. reduction in cost (%)	
Interstation distance (km)	Elevated	Underground
1	-	-
1.1	3.4	5.1
1.2	6.3	9.4
1.3	8.6	13
1.4	10.8	16.1

13. Entry/Exit in underground station is generally at the end. Thus effective distance between entry/exit of two consecutive stations in underground portion is less. **Average inter station distance of about 1.3 km or more should be taken in underground portion and more than 1 km in elevated portion subject to feasibility.**