FINAL REPORT:

Efficiency Analysis of Classroom Infrastructure for Primary Education in Bangladesh

May 2014

This report has been produced for Evidence on Demand with the assistance of the UK Department for International Development (DFID) contracted through the Climate, Environment, Infrastructure and Livelihoods Professional Evidence and Applied Knowledge Services (CEIL PEAKS) programme, jointly managed by HTSPE Limited and IMC Worldwide Limited.

DOI:http://dx.doi.org/10.12774/eod_cr.july2014.ripinetal

First published July 2014

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Report Summary

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Firstly, the team would like to thank **DFID (Dhaka)** in particular Mr. Fazle Rabbani (DFID Education Advisor) for supporting this study. For your guidance and openness for discussion we would like to thank:

MoMPE: Dr. Imtiaz Mahmud (Deputy Chief)

DPE: Mr. S K Ghosh (Diector General); Mr S.M Mesbahul Islam (Additional Director General). Mr. Manindra Nath Roy (Director Planning, DPE), Mr. Fazle Yahya (Deputy Director, DPE), Mr. Saiful Islam (Deputy Director, DPE).

LGED: Mr. Abul Kalam Azad (Additional Chief Engineer); Mr. M. Azizul Hoque (Superintending Engineer).
Mr. Mahbub Alam (Executive Engineer) for facilitating the site visits, providing required data and documents for our analysis. LGED Officials from Chittagong, Bandarban, Dhaka, Sylhet and Sunamgonj for their support in visiting the sites and providing required data.

DPHE: Mr. Saifur Rahman (Project Director, PEDP3). DPHE officials at Chittagong, Bandarban, Dhaka, Sylhet and Sunamgonj for their support on site visits.

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The number of people who have directly or indirectly contributed to this study are too numerous to name here, if inadvertently we have missed your name here, please know that the team is grateful for your help. A list of all meetings and site-visits undertaken by the team are provided in the appendix.

Abbreviations

ADB	Asian Development Bank
BOQ	Bill of Quantities
CW	Civil Works
DFID	Department for International Development
DPHE	Department of Public Health Engineering
DPE	Directorate of Primary Education
EED	Education Engineering Department
EMIS	Electronic Management Information System
GBP	Great Britain Pound
GEA	Gross External Area
JARM	Joint Annual Review Mission
LGED	Local Government Engineering Department
MoPME	Ministry of Primary and Mass Education
MTR	Mid Term Review
NGO	Non- Government Organization
NUA	Net Usable Area
PEDP	Primary Education Development Program
PWD	Public Works Department
SMC	School Management Committee
WASH	Water, Sanitation and Hygiene
WB	World Bank

SECTION 1

About this document

This document is the final report of the DFID supported study undertaken in April 2014. The primary purpose of this document is to advise senior staff at DPE managing the PEDP3 about the efficiency of physical infrastructure being built within PEDP3 and how it may be enhanced so that programme targets can be met within timeframe, quality and budget. At a meeting held at DPE on 30 April 2014, draft final recommendations from the study were presented and DPE suggested that this document should be written in a manner that its contents and implications were clearly distilled and could be widely circulated to a wider non-engineering audience as well. [Please read the footnotes throughout for explanation of any technical terms used in the text.] The PEDP3 is amongst the most ambitious primary education programmes anywhere in the world and will be a challenge for any institutions that undertakes to implement it. The report recognises the efforts of the PEDP3 team and institutions and hopes to make constructive and practical suggestions in line with technical and management practice required for a project of this scale.

SECTION 2

Context

The Directorate of Primary Education under the Ministry of Primary and Mass Education is implementing the Third Primary Education Development Programme (PEDP 3) from July 2011 over a period of 5 years. The programme is being funded jointly by the Government of Bangladesh's own resources and 9 development partners (including DFID). The *Local Government Engineering Department* (LGED) and the *Directorate of Public Health Engineering* (DPHE) are executing the construction works of the infrastructure development sub-component under the guidance of the DPE.

In order to make an efficiency analysis of the works of the infrastructure development sub-component the Joint Annual Review Mission (JARM) 2013 has agreed to conduct a study.' In view of this, the study team has been engaged with financial support from DFID.

The principle objective of this study is to recommend ways for efficiency gains in school, infrastructure construction in Bangladesh. From this we understand the requirement for future physical infrastructure to be child-friendly, resource-efficient and green to build, operate and manage over the entire life-cycle; resilient to natural disasters providing a better fit for the specific requirements of the users and enhancing learning and teaching practice.

SECTION 3

PEDP3 Programme Targets

One of the observations made by the team and widely acknowledged in stakeholder discussions is that factual data on programme targets and empirical data on progress-to-date is not as complete and accessible to partners working on this project (as it ought to be). This is an important factor in managing the overall efficiency of the programme, this report will return to this important point later.

The understanding of the consulting team is that at the start of the PEDP3 project the aim was to provide an additional 42,251 classrooms in 15,000+ locations that were confirmed with the highest need for good quality learning spaces across the 64 districts. The additional learning spaces are being built using an investment of 48.85 Billion Takkas under the PEDP3 programme[1]. An additional 11.48 Billion Takkas has been provided under PEDP3 for water, sanitation and furniture also across tens of thousands of locations[2].

It has not been possible to establish with accuracy how many of these learning spaces are actually being built in geographical zones with special needs for instance the coastal areas (prone to cyclones and floods), Haor (prone to extensive seasonal flooding) and Hills (prone to difficult topography)[3]. However the table below provides a reasonable estimate based on discussions with various stakeholders. Therefore, the costs and difficulties of creating additional learning spaces in the Coastal and Haor locations are likely to have a bearing on the overall efficiency of the PEDP3 programme. This is consistent with the discussions with stakeholders as the cost of construction across these regions is expected to vary because of the unique topographical and environmental constraints and characteristics.

	TOTAL (classrooms)	Haor (%)	Hill (%)	Coast (%)
Additional learning spaces proposed under PEDP3	42,251	15	8	30

An important number for the purposes of this study is the budgeted cost for classrooms in PEDP3. The cost of new 'usable learning space'[4] is pegged at 0.8 Lakh Takka/ sq.m. NUA. [see footnote for definition of 'usable learning space' and Figure 1 below for a diagrammatic

1 PEDP 3 Component 2.9 'Need based infrastructure development'.
2 PEDP3 Component 2.8 'School environment'.
3 Information was requested and a template was provided. The Quarterly Progress Reports (QPS) submitted to DPE should report progress accordingly. The significance of this is explained in this report.
4 'Usable learning space' is also referred as 'Net Usable Area (NUA)' in this report. It is defined as the net space left-over in the classroom for learning and teaching functions after deducting the space taken up by circulation, storage, structural elements like walls and columns, ancillary facilities (like toilets). Based on a study of PEDP3 prototype drawings, it is estimated that each classroom within PEDP3 generates approximately 15-16 sq.m. NUA or 'usable learning space'.

representation of NUA.] Significantly the same universal cost was applied across all districts of Bangladesh in PEDP3 while we know now that regional variations are highly likely.[5]

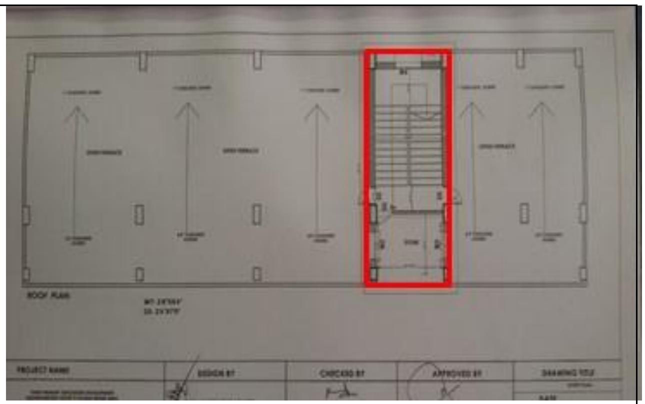

Figure 1: The example above visually illustrates Net Usable Area (NUA) and Gross External Area (GEA). The plan on the left shows the Ground Floor of a typical PEDP3 prototype with three classrooms and one teachers' room. The plan on the right shows the roof plan of the same building with the staircase. The GEA is the sum of all areas shown within the Red Rectangles. While the NUA is the sum of all areas marked yellow. The yellow spaces accommodate the workstations of students and teachers and any circulation spaces, toilets, structures, storage spaces are excluded in calculating the NUA. The important point is that an efficient building aims to achieve 30-40% of NUA in relation to the GEA. If the NUA/ GEA is lower than 30%, it implies that the building footprint or built area is far in excess than necessary to serve the learning space. [The above illustration is diagrammatic and not-to-scale]

5 Thus going forward knowing the actual number of classrooms being built in each region is vital to plan and monitor the programme properly.

SECTION 4

Efficiency framework

Consultations[6] identified that amongst stakeholders the most immediate interest was in enhancing efficiency related to the 'construction costs of physical infrastructure'. It is worth pointing out that efficiencies of construction cost and Usable Area are closely correlated though rarely highlighted. The team also came across a number of other priority including but not limited to good quality of child-friendly school environment and adequate maintenance of the infrastructure over its life-cycle. Discussions with LGED also highlighted their commendable aspiration that school infrastructure should be 'green' or in other words utilise natural resources efficiently and minimise adverse environmental impact.

Following the consultations a simple **CASp**[7] **framework**[8] is devised and presented here for capturing the efficiency of the infrastructure in progress. It should be borne in mind that the client's (DPE's) priority and focus is in achieving the required number of high-quality 'learning spaces' within the project timeframe and budget. Each new building or classroom should aim to generate the required and/or maximum amount of 'learning space'.

4.1 Construction Costs/ NUA

Empirical information from 'final bills' obtained during site visits is used to understand the market cost of newly built classrooms under PEDP3. Final bills for example sites[9] visited in Haor, Hill and Coastal site were analysed for cost breakdown, unit costs[10] and also compared for regional variation. As the sites visited in different areas use different prototypes, the costs/ NUA is used as the basis for comparison.

Of particular interest is in costs going over the budgeted amount of 0.8 Lakh Takkas/ sq.m mentioned earlier[11].

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6 A number of meetings were held with various stakeholders including a workshop with LGED/ DPHE/ EED engineers titled 'Child-centred, Green and Efficient School Infrastructure' held on 28th April 2014. The main suggestions from this workshop are in Appendix 5. A list of all meetings is in Appendix 3

7 CASp: Costs, Usable Area and Site planning.

8 Later on in the report a few indicators are proposed for the continued monitoring of the PEDP3 programme.

9 List of site visits is provided in the Appendices.

10 The PWD schedule of rates 2014 and PWD analysis of schedule of rates for civil works have been collected from the department. The DPHE submitted sample tender documents with cost estimates as well as final bills of quantities for wash block and water sources. Tender documents of Bangladesh education engineering department (EED) were collected. All departments mentioned above follow open tendering method (national). DPHE and EED do not have their unit rates and follow the PWD schedule of rates. However, LGED has its own schedule of rates and they follow their unit rates for preparing its engineers' estimate.

11 Resulting in the permanent/ semi-permanent prototypes compliant with the Bangladesh National Building Code. (NBC)

4.2 Net Usable Area NUA/ GEA

Empirical information based on published architectural and engineering drawings of 'prototypes' is used to calculate the 'net usable area (NUA)' obtained from each prototype. As described previously, GEA is the 'Gross External Area' is the total external footprint of the building counting all floors.

Five prototype designs being used by LGED in PEDP3 were studied. These include Vertical Extension (V_EXT)[12], Cyclone area school (CYCLONE), Char area school (CHAR), Flood/ Haor area school (FLOOD) and One storey building (ONE_ST). In these prototypes[13] the foundations and super-structure are designed for a building that could be extended upto 4-6 storeys.

Efficiently designed education buildings tend to achieve an NUA/ GEA of 30-40%. If the NUA is below this percentage, it may imply a larger than necessary building foot-print or built-area in an education building.

4.3 Site Planning

Observations from site-visits of newly built infrastructure under PEDP3 was compared with a checklist of good site-planning practice including making best use of existing assets, site drainage, user-centred location of facilities with adequate access and climatic design[14]. Site planning can influence the use, quality and longevity of the infrastructure and therefore plays an important role in the overall efficiency of the programme.

Existing assets on sites (and their condition) will determine the actual need for new construction and the extent of redundancy[15] to be designed into the structure. For instance the presence of an existing classroom that could be repaired or an existing building that could be extended may reduce the need for building an entirely new classroom or school building from scratch. This has significant implications for the efficient use of project resources.

Site drainage is vital in meeting the requirement for adequate and safe disposal of rainwater run-off as well as sewerage/ grey water from WASH blocks. Inadequate drainage on site will significantly reduce the life-expectancy of the school infrastructure.

Access and appropriate location can determine the ease and confidence with which students and staff will use facilities. Again visual observation was used to check for obvious issues related to access and location on site that could increase cost or reduce the benefit of the new infrastructure.

Climatic design of education buildings is primarily aimed at minimising thermal (heat or cold) stress and providing adequate natural lighting for teachers or students during school hours. This includes both building design and site planning related issues. The team visually

[12] A large proportion of new classrooms under PEDP3 are based on this prototype.

[13] Except CHAR and V_EXT.

[14] A Climatic Design checklist was developed for Sylhet, Chittagong and Dhaka locations using annual/ monthly averages for temperature, humidity and rainfall. We recommend developing a checklist with better locational precision for site planning using wind-direction data. Further down the report a 'help-desk' system is proposed to assist with site planning at district level. The study checklist listed 6 attributes that should have been met if every building was designed with climate and user comfort in mind, namely: East-West Orientation; 20-40% openings in the total wall area; single-banked rooms; light roof with insulation; protection from wind.

[15] Ability to expand or extend the structure in future.

inspected the southern face of the new classrooms and check if the expected climatic design features were present or not. The team also checked with the district level supervisors if they had applied or had access to basic tools for climatic design. Lack of climatic design will have a detrimental impact on the quality of the learning environment resulting in thermal stress. It also has a substantial cost implication where more electrical energy is used to provide lighting (electric lamps) and air movement for cooling (fans). Electricity is expensive in Bangladesh! Many structures will require lighter roofs and insulation for the users to be comfortable in hot and humid conditions across Bangladesh, this has implications for the cost of roofing material.

4.4 Other efficiencies

In addition the team also observed the following issues[16] that have a significant influence on classroom infrastructure efficiency:

- Is there adequate provision for life-cycle maintenance costs (best practice recommends 2-3 % of capital cost per annum[17]) and is the specification resulting in a demand for recurrent and maintenance expenditure that is unlikely to be available.

- Is the construction and maintenance manageable with the means and skills available to local contractors and communities?

- Do implementing partners feel they have adequate human resources, skills, tools and resources for delivering the classroom infrastructure?[18] This has an implication on the quality, timeliness and costs of delivery.

16 Identified through best practice as well as raised by PEDP3 stakeholders.

17 During discussions with stakeholders it has come up that maintenance costs are a recognised issue and over time the availability of maintenance funds has risen although nowhere near the recommended levels. As this is the case the team looked for issues where the specification was inappropriate in the sense it would lead to high levels of recurrent maintenance expenditure.

18 This was gauged through brief discussions with the personnel on the sites visited.

SECTION 5

Baseline observations

Baseline observations from empirical evidence are presented below[19].

5.1 Net Usable Area (NUA) / Gross External Area (GEA)

Figure 2 below demonstrates that other than the ‘Char’ prototype, the amount of learning space (or NUA) in other prototypes (Vertical extension, Haor, Coastal and Single storey building) is below the expected efficiency.

The implication is that the overall building and structural footprint should be optimised to increase efficiency.

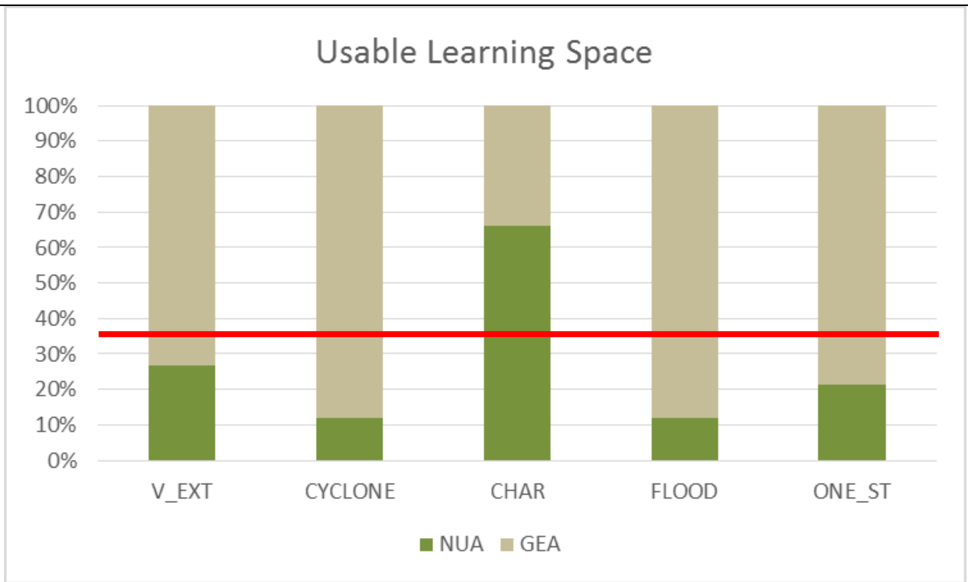


Figure 2: Net Usable Area (NUA) generated in various design prototypes within PEDP3. The red line indicates the target NUA/ GEA in an efficient education building.

5.2 Site planning

Optimising existing assets on site, Site Access and drainage: As the following images (Figure 3-4) illustrate nearly all the sites visited had pre-existing assets that could be better utilised reducing the demand for new infrastructure[20]. Personnel met at sites were unable[21]

[19] Site visits were made to schools in the districts of Chittagong, Dhaka, Sunamganj and Sylhet covering a variety of case-studies including vertical extensions, Hill/ Haor/ Coastal prototypes and urban areas.

[20] At none of the sites visited was the case clearly made for a four storey foundation taking account of existing structures that could be repaired or extended as the population grew or learning practice changed to being ‘subject based’.

[21] We found that the personnel on site were aware of these issues and also actively requested support in this area. However planning and capacity to deliver this needs to be enhanced.

to technically address needs assessment, drainage, climatic design and access issues. The implication is that substantial savings in cost and enhancement in quality are possible by enhancing technical and management support for such project scoping and site level planning. We have proposed a 'help desk' support system to which we will return later in the report.

Figure 3: [Clockwise from Top Left] **A 'One Storey School with Four Story Foundations'** built adjacent to an existing school building (built 2000) which also has structural provision for vertical expansion thus doubling redundancy; **A new school building built in a Haor site** while the pre-existing building and its raised ground is currently un-utilised. Substantial costs could be saved by repairing the existing building or even using the existing high-ground; **A WASH block** placed next to a tree, the structure is now highly prone to damage; **In the Haor** finding suitable locations is an important consideration and has major cost implications. **A WASH Block** with window obstructed by a column on the adjacent plot. [Photos R Kalra (Haor) and O Rehman (Chittagong) 2014]

Figure 4: [Clockwise from Top Left] **A 'Vertical Extension'** built atop/ adjacent a building that requires repair; **A WASH block** has restricted access; **A 'Vertical Extension' and WASH block** are added to a building built by the SMC. The WASH block opens into a classroom and the first floor is served by two separate staircases. A pre-existing one built by SMC and a new one built under PEDP3. Avoiding such duplication of construction at 'site-planning' stage can enhance both the Area and Cost efficiency of the classrooms. [Photos R Kalra 2014]

Climatic Design: The team observed that in almost all cases classroom design and orientation could be better applied. In all cases the roofs are heavy, with no insulation. Shading from trees has been provided in many cases. The implementing partners do not have basic information (such as local wind direction) and tools (computer aided simulation) for such planning - increasing the chances of thermal stress amongst both teachers and students and cost escalations as explained earlier. During the consultation workshop the engineers repeatedly pointed to the need for site masterplans for the appropriate design and siting of buildings.

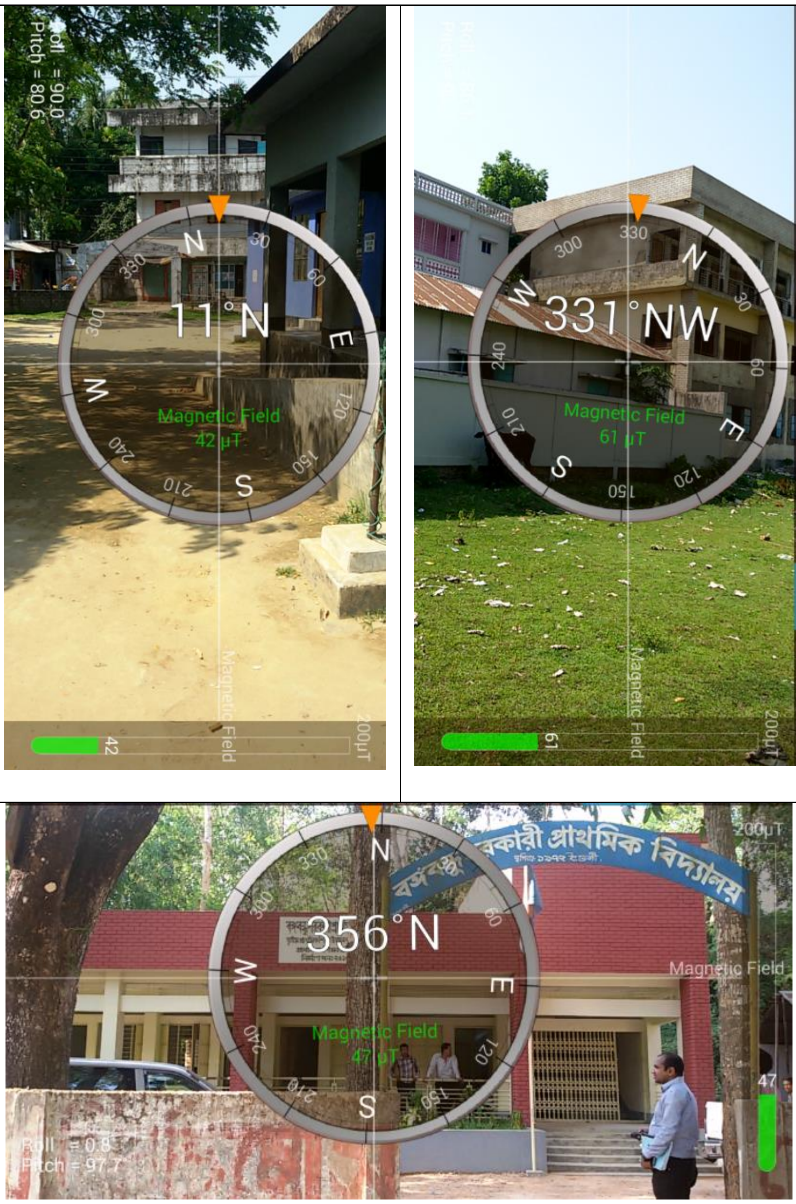


Figure 5: South face analysis of the various new classrooms built under PEDP3. In some instances, such as the image in top right, the southern face of the building was entirely blocked from view by other structures. [Photos R Kalra 2014]

5.3 Construction Costs/ NUA

A review of the final bills from case-study examples shows that:
-Structural steel and concrete by far are the pre-dominant costs in each of the three examples, it was found about seventy percent of total work involved in concrete sub-

structure, super structure, brick work, steel work without any piling work. The value of steel reinforcement work excluding other metal work is more than thirty percent of total civil construction component. (Figure 7)

- Door/ windows/non-structural metalwork and plaster/ paintwork are also substantial proportion of the costs in all three locations. It is worth noting that painting of the classrooms is a significant and recurrent cost at levels that the school will not be in a position to keep up with. This is clearly evident from the condition of structures that have been built as recently as within last 10 years.
- The 'Haor' and 'Coastal' example exceed the average budgeted cost by + 20% while the 'Hill' example is well within the budgeted cost. As mentioned previously the costs are closely related to the area efficiency. (Figure 6)
- A detailed breakdown by costs for each component[22] across the three examples is provided in Appendix 6.

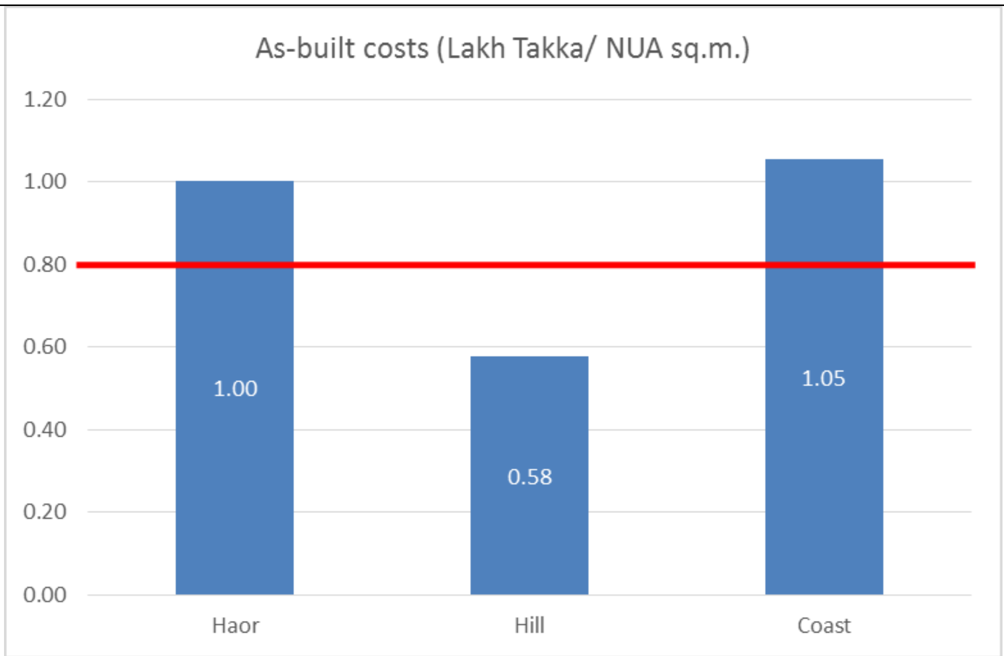
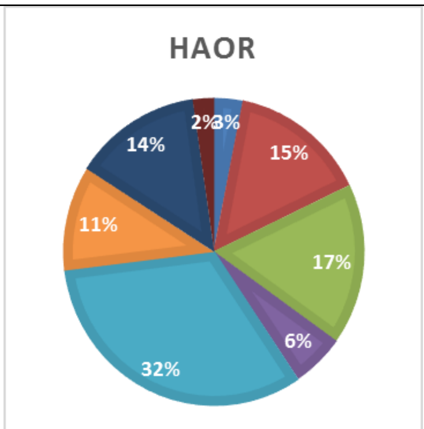
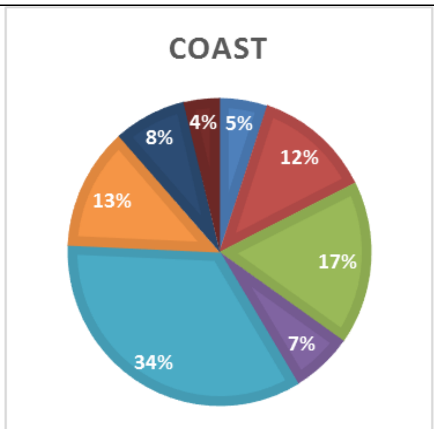


Figure 6: Comparison of the As-built Costs/ NUA or the three example sites in Hill, Haor and Coastal area. The red line indicates the PEDP3 average budgeted cost.





22 See also note on unit rates in Appendix 06

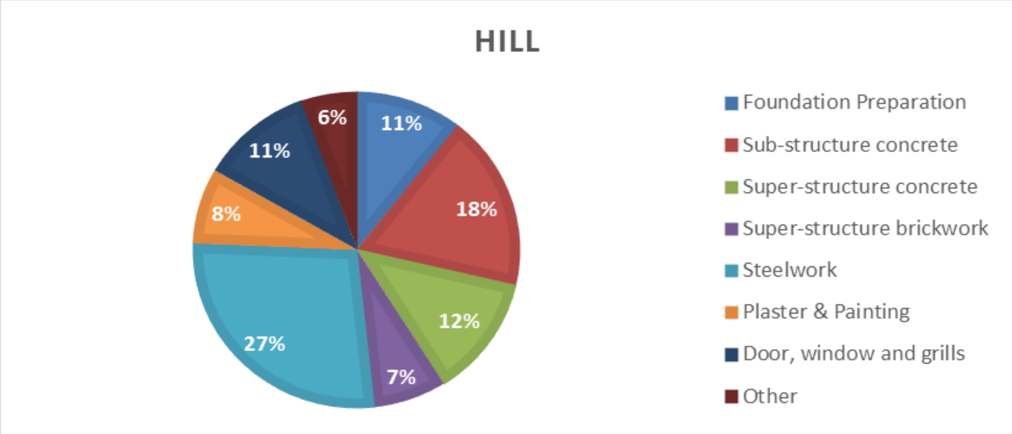


Figure 7: Comparison of cost-breakdown from three examples from Haor, Hill and Coastal area shows that structural steel and concrete are the predominant cost across the three examples.

5.4 Other efficiencies

The team made a number of relevant notes mainly from discussions with stakeholders in Dhaka as well as in the districts.

Quality of reinforced concrete works is a major issue particularly in coastal areas where the life-cycle of the reinforced concrete is affected by quality of works[23]. Schools in these locations will need higher investment in quality monitoring and assurance. A cue can be taken from private sector delivered projects in these locations and as a result of enhanced monitoring unit costs are indeed higher. However discussions with stakeholders could not provide an accurate number of new schools being built in these locations. It is important to know this number so that the budgets can be calibrated accordingly and additional costs can be offset with savings elsewhere.[24]

The team saw several classrooms where furniture was clearly an obstruction rather than aide to learning - taking up space and restricting easy movement. In many cases the furniture was clearly too bulky for both students and staff. The bulk is also damaging newly laid floors in some instances. In other places it has been stacked to clear space for interactive class activities. Clearly a more portable/ stackable specification with sharing[25] will improve the balance of furniture and usable space. On the other hand, more storage space will become necessary once portable IT equipment is introduced within the schools, as is planned under PEDP3.

The team did not see evidence of IT being integrated within classroom design. The implications are that further works may be required in future to adapt the classroom environment. This includes additional electrical charging points, blinds to avoid direct light on screens and suitably secure storage spaces as already mentioned.

23 Based on discussions with local stakeholders during the study.

24 In our discussions it was pointed out that the specification of metals in coastal and saline areas had to be thought through carefully as these were prone to rapid corrosion in these regions. Also if damaged, metal connectors and components are harder to replace if they require specialised training or equipment such as those involved with welding. As such if alternatives are possible in wood or other such material that is less prone to corrosion, requires a lesser degree skill and cost in maintenance and can be suitable managed using local skills it is preferable and will be more less costly in the long run and will save time in implementation.

25 As is commonly practiced in primary schools in both developed and developing countries.

The team observed some of the older classrooms were longer and appeared better adapted to flexible learning practices or invigilation during school-wide exams, particularly as it made it easier to manage combined spaces with smaller number of staff.

While talking to implementing teams at the district level, the study team also observed that they were lacking in analytical (checklist type) and CAD tools necessary in particular for site planning and needs assessment[26] on site.

Contractors, in particular in the Haor area raised the issue of transport costs bearing heavily on their budgets. The 'last-mile' costs of transporting material in small quantities to site using small vehicles, boats and often manual labour was adversely affecting their productivity and increasing costs. The contractors were open to the option of producing 'blocks' on site.

Figure 8: [Clockwise from Top Left] Observed furniture in classroom can be bulky and obstructive for certain types of learning activities; A classroom in Sunamganj uses the floor for learning activities; An example of roof insulation built and installed by the SMC in Sylhet to reduce thermal stress; A Madrasa building in Sylhet uses high-quality local organic material for walls, partitions and structural frames built using local community skills. [Photos R Kalra 2014]

26 The team did see the form filled out by schools which were then sent to Dhaka for overall needs assessment.

5.5 Workshop with engineering community

A workshop on ‘Child-friendly, Green and efficient education infrastructure’ was organised on Monday, April 28 2014 at the LGED offices in Dhaka. (Figure 9) More than 20 engineers from LGED, DPHE and EED and representatives from the DPE attended the workshop to confirm a shared definition of green and efficient. Divided into Haor, Hill, Plain and Costal groups they raised region specific issues and proposed enhancements in design and practice for efficient and green infrastructure, identifying any support they would require in achieving these. The measures proposed at the workshop were quantified by study team into any resulting cost-implications for the project, whether they be savings or additional costs. These have been included in the measures descried in the next section. Amongst these the workshop highlighted the requirement for improved support to site-planning and a number of ways in which construction costs could be reduced.

Figure 9: A workshop on ‘Child-friendly, Green and efficient education infrastructure’ was organised on Monday, April 28 2014 at the LGED offices in Dhaka. More than 20 engineers from LGED, DPHE and EED and representatives from the DPE attended the workshop. [Photos R Kalra 2014]

SECTION 6

Proposed measures and impacts

Measures identified through stakeholder discussions (including engineers' workshop) and the team's own suggestions have been collated in the table below. At the outset it was agreed with the stakeholders that further major changes in classroom sizes and layout itself are not essential at this stage. This will prevent any major reworking of the prototypes, however some structural refinements are required. The table below lists the measures and their potential impact on enhancing the CASp efficiency of the PEDP3 classroom infrastructure. Many of these measures and principles will equally apply to WASH infrastructure. After this table below the report presents the collated financial impact of these measures on the overall cost of example buildings in Haor, Hill and Coastal area. Note these are not an exhaustive list!

Measure Type	Efficiency and Green Measure(s)	Anticipated Impact	Recommended Follow-up
Site Planning	• Check existing assets on site (and condition) to confirm demand for additional classroom spaces before tender package finalised. • Ensure adequate site drainage [provide aprons around the building as standard]. • Implement climatic design checklist. [lighter roof[27] and insulation and building orientation included]	• Saved cost by maximising use of existing assets on site.[28] • Reduce life-cycle maintenance and repair costs from storm-water related damage. • Reduce operational cost of using fans & lighting and increase comfort of staff and students.	Set up 'help-desk' system at District level for timely support to 'Site-planning' using assessment checklists[29] and CAD based planning tools.
Prototype school designs.	• A school 'prototype' with Two storey foundation should also be produced	• Cost savings in major structural items and related [31] transport	Produce a 'lite' version of the existing school prototypes for tender packages.[32] Bolt-on

[27] 20-30% less mass from current roof. There are several options without resorting to CGI roofs. An RCC slab can be designed as a filler slab to achieve this for instance. Alternatively reflective roof surfaces will also achieve this.

[28] A cost line of 75,000 Takkas for 'help-desk' support on 'site planning' is proposed to apportioned in the budget for each site where new classroom or schools need to be added.

[29] We believe a checklist for assessing the condition of existing assets is already being prepared. This can be conjugated and packaged with relevant necessary assessments related to future growth, physical site features and climatic requirements. The overall package should be used to confirm the scope of each tender package. As discussed with DPE on 30th April 2014, it is OK to have standard prototype designs but tendering them without confirmation of actual requirements is resulting in over-building and reduced Usable Area efficiency. This process is unlikely to delay tender packages as the assessment is necessary but not necessarily time consuming.

Measure Type	Efficiency and Green Measure(s)	Anticipated Impact	Recommended Follow-up
	as a standard starting point. [30]	costs of structural steel, concrete and brickwork. [see footnote]	additional specification as per 'help-desk' assessment.
Furniture and Equipment	• Operate a Share furniture system across school instead of filling every classroom with furniture. • SMC to select from pre-approved catalogue of child-friendly light and stackable/ foldable furniture. They could even build their own from the available budget following guidelines. • SMC play a role in decision-making on how much resources are spent on furniture or other alternatives such as play equipment etc:	• Furniture and play-equipment costs reduced by 50%. • Working on ground or low tables is widely practiced in primary schools around the world and may be better suited for interactive learning. (Figure 10)	Consider IT equipment when planning which furniture to purchase. Storage will become important priority when IT equipment starts to arrive in schools. Light digital tablets do not require furniture and can be used on laps. Avoid Desktop PCs, they are not fit-for-purpose in a primary school environment as heavy-duty operations are not needed.

Figure 10: [Clockwise From Left] Bangladesh has excellent local materials [wood/ rope] and skills for play equipment such as the ones shown below; Primary Level Children can work more interactively sitting on the ground rather than using desk and benches. [Pictures from Dhaka and London, R Kalra 2014]

31 Cost savings of at-least 20% in concrete and at-least 20% Structural Steel are possible from a combination of changes that will result from new standard design with 2-storey foundation. Preference should be given in low-growth areas to load bearing structures. Assume Concrete in foundation will be possible to reduce by 20%, Concrete in superstructure will reduce by 10% as a result of optimisation in beams and columns, 20% structural steel reduction and 10" brick work will reduce by 20%. Proportionate savings from such measures will be greater in Vertical Extensions. Avoid building planters and build a more gentle ramp. Locally made blocks can also substantially reduce transportation costs. Use of higher grade Steel will reduce both quantities and Cost. In WASH blocks it is not necessary to use 10'' brickwork for walls, leaner blocks prepared on site and stabilised with cement can be used, saving also on transportation costs. Where boundary walls are required, use green hedges that have a much lower life-cycle cost and can be managed by SMC.

32 Aim to reduce the volume of structural steel and concrete by min 20%. Produce two versions: one with load bearing walls and the other with a framed RCC structure.

30 In compliance with Bangladesh National Building Code (BNBC). 4-6 storey foundation 'prototype' should only be used in the tender package if the case for future growth or change in teaching practice that will require additional space has been confirmed for a location.

Incremental Development	• Avoid building staircases, stairwells, chilekotha and roof parapets until the vertical extension is actually being implemented.[33]	• Costs of several structural elements is saved[34]. Time is saved by avoiding unnecessary construction.	If extension is not imminent then remove staircase and some related elements from tender package.
Standardise	• Standardise room sizes • Standardise good quality casting formwork so it can be given on loan and shared[35]. • Standardise good-quality block making equipment for lending and sharing.	• Cost of hiring equipment for block making is added to site budget. Savings in cost of material, skilled labour and transport. Promotes use of local material for block making.	Incorporate in architectural and engineering design refinements of PEDP3 prototypes and make suitable changes in specified quantities.
Flexibility and adaptation	Replace intermediate walls, with flexible partitions[36]. SMC to carry out minor adaptations in the building in the first few years such as adding flexible partitions, blinds.	Upto 50% reduction in costs of 5'' Brick partition walls. Promotes SMC involvement and skills. Allows for changing learning trends such as 'subject based' learning.	Incorporate in architectural and engineering design refinements of PEDP3 prototypes and make suitable changes in specified quantities. Add a line for 'building

33 Hundreds of staircases being built in the schools under PEDP3 will not be used for many years to come. However the investment in staircases, stairwells, protective gates at ground and upper floor is substantial. For maintenance a detachable and secure access (using ladder) can be sufficient. Roof that is only accessible to maintenance staff does not require extensive parapets and generous sizes of drainage elements should be provided with the provision to attach RWH (Rain Water Harvesting) apparatus particularly where electricity to operate water pumps for WASH blocks is not available.

34 6-7 cum concrete from staircase alone can be deducted as well as a proportionate amount of structural steel. Supporting structural members can be retained in the design for supporting the staircase in future if confirmed that growth will be necessary.

35 The team observed that the rural and remote communities in Bangladesh (such as in Haor) are very used to hiring machinery for seasonal works as observed during site-visits by watching the harvesting process. They are also master logisticians.

36 Remove some 'partition walls' from tender packages. Incorporate allowance for adding flexible partitions in architectural and engineering design refinements.

			adaption' under budget.
Maintenance	Include a 2-3% annual maintenance allowance to increase efficiency.	Maximise building life-cycle.	We understand this is a recognized issue and well on the agenda.

The cumulative impact of the measures described is illustrated below in the cost (Figure 11) and usable area (Figure 12) efficiencies for the three example sites.[37]

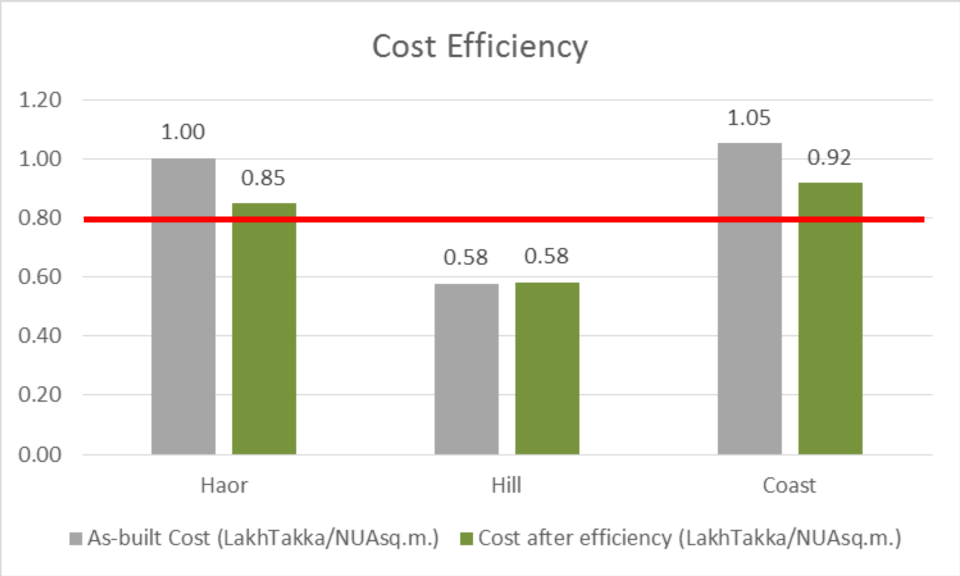


Figure 11: Changes in 'cost efficiency' after unit price review and applying efficiency measures including civil works only. With furniture/ play equipment cost reductions the overall reductions are even greater in all three sites. Note that to implement efficiency measures costs have also been added for site-planning, equipment hire, building adaptation. Overall there is still a cost reduction.

37 See Appendix 6 for more detailed breakdown. The results show the changes from unit price adjustments (based on site interviews) as well as applying the various efficiency measures described above.

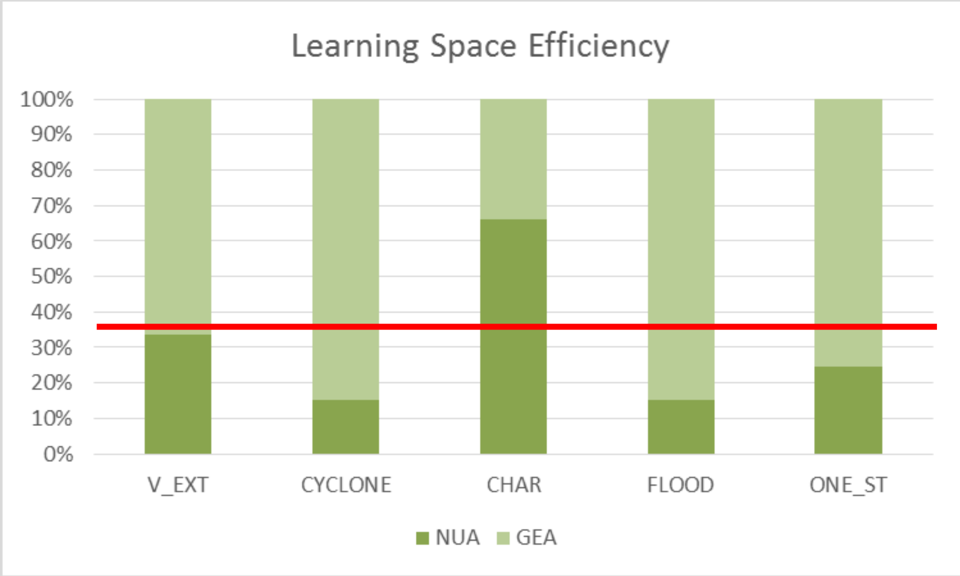


Figure 12: Learning space efficiency is improved (particularly note the efficiency gains made in V_EXT) the most prominent prototype in PEDP3 after applying efficiency measures.

SECTION 7

Concluding remarks

The PEDP3 is amongst the most ambitious primary education programmes anywhere in the world and is a logistical and technical feat for the experienced institutions undertaking its implementation.

In terms of physical infrastructure PEDP3 aims to provide 42,251 additional classrooms using a programme investment of 48.85 Billion Takkas. An additional investment of 11.48 Billion Takkas is being made into WASH facilities and furniture across thousands of sites.

The implementing institutions have expressed a commendable vision for child-centred, green and efficient infrastructure which implies optimising the use of material resources and minimising environmental impact.

The study team looked at a number of issues that have a major influence on the quality and efficiency of the PEDP3 infrastructure including the space efficiency, cost efficiency, site planning issues including maximising the use of existing assets on site. The study observes, that in each of these there is need for improvement in order to meet PEDP3 targets within time, budget and to the desired quality. In the example sites where final bills were studied the cost/ NUA varies by location both above/ below budget by as much as 20%. It is due to the demands of the location but also front-loading of many design elements related to future expansion, the case for which isn’t always presented.

Several practical efficiency measures have come up during discussions with stakeholders. The study team has been able to translate the measures they proposed into cost implications for the project. In all cases there appears a strong link between low space efficiency and cost over-runs. Every effort should be made to make good use of existing assets and avoiding but the most immediately useful structural or circulation elements in new building (these can be added if necessary in the future).

In meeting project targets measures should be applied across all regions, essential cost over-runs in one type of location will be off-set very likely by savings in other.

The PEDP3 will need to support[38] the implementing partners at district level in applying these measures using the most appropriate tools and techniques [such as ‘condition assessment’ checklist and ‘site-planning’ checklist] so that tender packages can be finalised with more accuracy.

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[38] and collate real-time data possibly through a ‘help-desk’ system.

SECTION 8

Proposed next steps

The study team would like to propose the following steps after this study to be undertaken by the implementing partners:

- **Prototype revision:** LGED/ DPHE refine the standard prototypes based on measures suggested in this report. Accordingly modify the quantities and cost-line items based on suggested measures. [Technical meetings with partners such as LGED and DPHE should be arranged to brief them on measures and clarify any details.]
- **Demand assessment package:** Final package of standard site-assessments to gauge condition of existing assets. We understand this is already being developed and have made suggestions on the scoring system that may be used. That discussion can be developed further.
- **Site-Planning Help-Desk:** Strengthen 'help-desk' type technical support on site-planning at district level. [A specification for the help-desk can be written on how it can operate and to equip it appropriately. The suggestion has already received support from some stakeholders.]
- **Real-time data:** Prioritise relevant real-time data to be widely reported amongst stakeholders for project monitoring. Particularly key is the region-wise status of completed and ongoing projects to capture cost variation. We believe a web based system is already being developed and we support that.

Annex 1 Inception Report and Terms of Reference

Please download from following link
https://drive.google.com/folderview?id=0B57cO364owSWaEt6cGRoczRtN28&usp=sharing

Annex 2 List of documents received and referred

Please download from following link
https://drive.google.com/folderview?id=0B57cO364owSWaEt6cGRoczRtN28&usp=sharing

Annex 3 List of meetings

Please download from following link
https://drive.google.com/folderview?id=0B57cO364owSWaEt6cGRoczRtN28&usp=sharing

Annex 4 Questionnaire(s) used on site-visits

Please download from following link
https://drive.google.com/folderview?id=0B57cO364owSWaEt6cGRoczRtN28&usp=sharing

Annex 5 Workshop ‘Child friendly green and efficient infrastructure

Please download from following link
https://drive.google.com/folderview?id=0B57cO364owSWaEt6cGRoczRtN28&usp=sharing

Annex 6 Detailed cost breakdown from case-study sites

HOAR	As-Built prices[39]	After unit prices reviewed	After efficiency measures[40]
Foundation Preparation	193,994.84	197,198.06	197,198.06
Sub-structure concrete	917,778.60	807,869.10	646,295.30
Super-structure concrete	1,061,096.40	973,955.30	876,559.80
Super-structure brickwork	351,057.00	364,938.00	321,837.10
Steelwork	2,020,046.50	2,018,289.90	1,614,631.90
Plaster & Painting	685,962.90	364,738.90	364,738.90
Door, window and grills	849,399.90	849,399.90	849,399.90
Other	140,600.20	140,600.00	391,420.00
CIVIL WORKS TOTAL	**6,219,936.34**	**5,716,989.16**	**5,262,080.96**
Furniture	**278,252.00**	**278,252.00**	**139,125.00**
TOTAL	**6,498,188.34**	**5,995,241.16**	**5,401,205.96**

HILL	As-Built prices	After unit prices reviewed	After efficiency measures
Foundation Preparation	473,973.80	494,767.39	494,767.39
Sub-structure concrete	801,392.28	818,880.56	655,104.45
Super-structure concrete	554,449.49	579,157.18	521,241.46
Super-structure brickwork	322,378.30	387,279.23	340,582.35
Steelwork	1,219,699.59	1,395,819.24	1,119,354.00
Plaster & Painting	342,318.78	313,587.84	313,587.84
Door, window and grills	499,744.69	499,744.69	499,744.69
Other	242,559.73	241,559.73	541,151.70
CIVIL WORKS TOTAL	**4,456,516.66**	**4,730,795.86**	**4,485,533.88**
Furniture	**278,252.00**	**278,252.00**	**139,125.00**
TOTAL	**4734768.66**	**5009047.86**	**4624658.883**

39 From Final Bills received from site.
40 Including measures proposed at Engineers workshop.

COAST	As-Built prices	After unit prices reviewed[41]	After efficiency measures
Foundation Preparation	269,545.13	281,117.90	281,117.90
Sub-structure concrete	657,574.64	676,184.23	540,947.39
Super-structure concrete	907,082.00	749,678.53	674,710.00
Super-structure brickwork	345,610.07	393,072.56	337,909.19
Steelwork	1,809,805.35	1,841,959.25	1,473,567.40
Plaster & Painting	675,028.34	370,447.41	370,447.41
Door, window and grills	408,691.34	408,691.34	408,691.34
Other	196,322.91	196,322.91	503,230.00
CIVIL WORKS TOTAL	**5,269,659.78**	**4,917,474.13**	**4,590,620.63**
Furniture	**171,870.00**	**171,870.00**	**85,935.00**
TOTAL	**5,441,529.78**	**5,089,344.13**	**4,676,555.63**

[41] The study team prepared its own analysis of schedule of rates for a) 75 mm thick CC work, b) RCC work in sub-structure, c) RCC work in super-structure, d) 10 inch brick work, e) 5 inch brick work, f) Steel work, g) Plastic paint and h) Exterior paint. The PWD analyses of schedule of rates have been followed with modification for labour and material rates. The team analysis added water charge separately. Actual cost of labour and materials identified from different sources based on different zones in Bangladesh. The team visited three types of building sites, costal, hill and haor and interviewed contractors for per day labour rates of head mason, mason, rod binder, daily labour. Present market rates of material such as bricks, sand with FM 1.5, sand with FM 2.5, cement, mild steel were also taken from the contractors. With these market rates, transport cost being more for hill, haor area and teams' own judgment a realistic schedule of unit rates for the above mentioned items have been established. All these unit costs were compared to the costs of LGED and current published rates of PWD.
The individual item rates in the schedule of rates of LGED and PWD's do not vary in different areas/zones of Bangladesh but the "team" unit rates for different items varied for haor, coast and hill areas. PWD rates for concrete works have two parts i) concrete unit rate per cu. m. and ii) concrete shutter rate per sq. m. whereas LGED and "team" unit is cu. m. for concrete work.
Concrete works unit rate in haor, coast and hill areas are 10%, 20% more and 3% less respectively than the "Team" unit rate and 25%, 1% more and 9% less than the LGEDs' unit rate. It is to be mentioned that in hill area, the local contractor of hill tribes are exempted from taxes, so that may be the reason that the rates are more competitive though the transport cost is high there. Ten inch Brick work unit rate in haor, coast and hill are 7%, 13% and 18% less respectively than the "Team" unit rate and 1%, 8% and 13% less than the LGEDs' unit rate and 6% more, 2%, 7% less respectively than the PWD unit rate. Mild Steel works in the above areas are very competitive and unit rate varies only by 2% except the hill unit rate from the "Team", LGED and PWD unit rate. Unit cost rates are high in Haor area and low in Hill area.