Proposed Model for Enhancing Performances of Small Projects in Small Island States – Case Study of the Republic of Mauritius

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Abstract. In this study the sources and causes of poor performances on small residential building projects, within the island of Mauritius, were used to devise a model that would enhance success on such types of construction ventures. The model was initially tested and refined. During the observational studies, 18 houses were observed within various districts around the island. Throughout the investigation, no two houses were constructed by the same builder/labour contractor or team of workers. For the validation of the proposed system, the same 18 teams were contacted. However, to form part of the selection list, the following criteria were mandatory: (i) the Builder/Contractor had to be agreeable to follow the proposed framework and, as per the previous endeavour, will supply only labour; (ii) the Client was also agreeable to follow the proposed model; (iii) residence was less than or equal to 1615 square feet; (iv) the residence was only one level high; (v) the residence was made of reinforced concrete elements and cladded with cellular blocks; (vi) construction started in August 2017; and (vii) the consultant on the project was myself. The impact of the system on the different projects proved to be very successful on many frontiers. The constructions were executed within the expected budgets with very little or insignificant deviations. Duration of projects was as expected and the quality of the resulting works was above average industry standard. Health and safety recommendations were implemented on all of the sites with the result being zero major/fatal accidents. Wastage on site was reduced considerably. Feedbacks collected with the different stakeholders were all positive, which proved that the proposed framework had boosted the performance of these residential building projects.

1. Introduction

During the last decade, a noticeable growth has been witnessed in the construction of high-rise apartment buildings around the island. However, the majority of Mauritians still reside in individual low-rise dwellings. Gupta et al. [1] have clearly defined numerous factors and characteristics that categorise such buildings. The residential building stock, as per the annual digest of statistics [2], clearly illustrates the rise in the numbers of residences over the years, figure 1. On average, some 4,268 building and land use permits (BLUP) are delivered annually for the construction of such new houses. As per figure 2, a variety of building materials can be used for development. However, concrete, due to its lower price per cubic metre, is by far the preferred construction building material. Most residences are made up of a structural skeleton made up of reinforced concrete columns, perimeter beams, flat and mono-pitched slabs with the perimeter masonry wall built of cellular blocks bonded altogether by a cement-based mortar.

In Mauritius, within the residential building sector, the success rate is low for many apparent reasons (inadequate resources due to its insularity among others). The construction of residences, which according to Salvadori [3], is one of mankind’s most expensive financial investment need to be studied carefully, and new performance frameworks developed that will increase the likelihood of the venture(s) being a success.
Small residential building projects, due to its lower project value, cannot afford consultants to ensure that the works are done according to the drawings and specifications. In this particular investigation the intent is to come up with a framework that will replace the consultants and at the same time ensure that the construction is done within cost, time and of quality matching at least average industry standards.

2. Methodology
The methodology adopted for this study is described next. The different activities associated with residential building projects prior to the start and during the execution of the works were classified into two distinctive phases; pre-construction and construction phases. Issues such as missing details, inadequate specifications, and improper quality control among others were found to impede on the performances of specific residences, following an observational study of 18 dwellings satisfying the following characteristics, namely; (i) residence’s floor area did not exceed 1615 square feet; (ii) the building comprise of one story only; and (iii) the structure will be made of reinforced concrete columns, beams, slabs cladded with cellular blocks bonded altogether with a cement mortar. The proposed model was devised to take care of all those identified problems. After testing and making refinements to the framework, it was applied to on real residential construction projects.

3. The Proposed framework
The framework is organised into two parts, I and II. Part I is based on the pre-construction phase while part II deals with the construction phase.

Part I – Within this section, it is assumed that the client has negligible to no experience in the construction of houses. Hence, there is a need to appoint a consultant with a specific scope of works and financial package to help the client in understanding the proposed construction. After going through the plans with the clients, changes will have to be documented, and plans amended accordingly. The need to apply for an amended BLUP will depend on the extent of the amendments being done. The consultant will have to be very explicit on the impact of changes during the execution of the contract on the overall budget of the project.

The next step is the appointment of the labour contractor/team of workers. Once selected, the contractor will have to fill all the required forms and understand the conditions of the contract. Working sessions will then be organised with the selected contractor where all queries, missing information and works methodology, as well as site administration, will be discussed. The outcomes of these meetings will lead to the establishment of the construction methodology, the required plant and equipment, a detailed programme of works with a start and an end date, and a Bill of Quantities (BOQ) that will be used for cost monitoring purposes.
Part II - This part of the proposed system deals with the construction phase, which may be summarised into three stages, namely:

(i) construction of the sub-structure;
(ii) construction of the super-structure; and
(iii) finishing works.

The proposed framework adopts a continuous and an iterative process. For every of the phases mentioned above, similar steps will be adopted. Before the start of any phase, the consultant will ensure that the materials are all compliant with the works and the workers know, exactly, what tasks will have to be executed and in which order. The labour contractor will have to ensure that the jobs will be performed according to a planned scheme of works, without risks and efficiently by the workers. Clients will have to ensure that the changes are kept to a minimum.

During the execution of works, the contractor will have to ensure that works are being executed according to plans, specifications, methodology, POW and any queries/variations identified are tackled together with the consultant and client. The labour contractor should have an internal quality system in place.

Consultants will have to ensure that works are being executed according to specifications, drawings and that progress is as per POW. Any defects noted will have to be corrected and hence reworks avoided/minimised. Any queries/issues brought to the attention of the consultant will have to be tackled altogether with the client and contractor.

Clients will have to ensure that the changes are kept to a minimum. The right platform to minimise the likelihood of change orders occurring is during the brainstorming sessions.

Prior to the start of the next phase, a meeting will be scheduled with the different stakeholders involved in the project to reflect on what went wrong during the previous stage(s) and what needs to be done to avoid repetition of such incidences. Furthermore, working sessions on the next phase will also be entertained. The whole process will be followed until the end of the construction period.

The proposed framework described, in this section (figure 3), has taken all the parameters that could enhance the performance of the construction of residential building projects into consideration. Both perceived factors, as well as observations made during the study of the residence in construction, were utilised. Pre-testing of the proposed system involved its application on actual construction site with working sessions with both the client and builder. This process was repeated until the no further refinements were required. The next phase of this study is to test the proposed framework and gauge its proposed benefits.

4. Testing of the proposed model

During the observational studies, 18 houses were observed within various districts around the island. Throughout the investigation, no two houses were constructed by the same builder/labour contractor or team of workers. For the validation of the proposed system, the same 18 teams were contacted. However, to form part of the selection list, the following criteria were mandatory:

- The Builder was agreeable to follow the proposed framework and will supply only labour.
- The Client was agreeable to follow the proposed model.
- Residence was less or equal to 1615 square feet.
- The residence is only one level high.
- The residence is made of reinforced concrete elements and cladded with cellular blocks.
- Construction started in August 2017.
- The consultant on the project was myself.

[Justification for being the Consultant myself: Academically, I possess a first bachelor degree in Civil Engineering from the University of Mauritius (1998) and a Master degree in Civil Engineering with specialisation in construction engineering and management from Iowa State University of Science and Technology (USA, 2008). Professionally, I have been active in the industry for the past 18 years and have more than 15 years of engineering practice post my registration with the Council of Registered Professional Engineers of Mauritius.

After a briefing session on the purpose of the study, all Builders/Team of workers and Clients that were contacted, manifested their interest to be part of the experiment. However, when applying the above criteria, only ten projects made the selection list.
PROPOSED FRAMEWORK FOR RESIDENTIAL BUILDING CLASS

Client
- Having little to no experience in construction.
- Appoints "Consultant" (Doc. 01)

Brainstorming With Client
- Consultant needs to ensure that Client understands what is being constructed, Client is comfortable with the proposed sizes of the different units and understands the DOs and DON'Ts during construction according to the proposed checklist.

Following the brainstorming session, three possible outcomes are possible. (Doc. 03)

Outcome 1
- No changes to the proposed plan

Outcome 2
- Changes within the perimeter of the proposed residence with no incidence on footprint.

Outcome 3
- Changes whereby the footprint is either increased or decreased.

Update Drawings
- Amended drawings need to be approved by the Local Authority.

Quotation is requested from labour contractor.

Appointment of Labour Contractor (Doc.04)
- Contractor needs to be qualified for the job and should fill all the relevant forms as per the terms and conditions of the contract.

Brainstorming Session with Contractor (Doc.05)
- Consultant needs to ensure that Contractor understands the project, has no queries and any missing information from the plans are provided.

Following the brainstorming session, the following three outputs are achieved.

Output 1 (Doc.06)
- Construction methodology with list of plant and equipment is clear to Contractor.

Output 2 (Doc.07)
- Programme of Works with a start and end date is produced and will be used to monitor the project.

Output 3 (Doc.08)
- Bill Of Quantities is finalized and will be used as a cost monitoring tool.

Start of Project
- Construction starts off.

Construction of Sub-structure
- Construction of Super-structure

Finishing works

PROJECT SUCCESS

During Execution of Works
- Consultant to approve all the works; check for quality of works to avoid defects, reworks and minimizing wastage; Monitor Programme of Works; Monitor Cost; Schedule weekly meeting with contractor’s team to ensure that works are being executed according to plans, specifications and Programme of Works. Difficulties and queries are being sorted out.
- Contractor to execute works according to plans, specifications, methodology and Programme of Works; have all the works approved by consultant; Ensure team members are executing their respective works efficiently and according to Health and Safety regulations; Ensure that all queries and issues are tackled together with the Consultant; Any foreseen variation(s) are documented and presented to Consultant.
- Client to ensure that no change orders are given during construction otherwise there will be cost implications.

Proposed checklist to be followed by all. (Doc.09)

After Execution of Works
- Prior to start of the next phase all stakeholders to brainstorm on the works that were executed and to note what went according to plan and what did not. Variations need to be tabulated and its cost implications determined. The project status with respect to the following will have to be determined, namely: Cost, Time, Quality and Health and Safety.
- Proposed DOC. to be followed by all. (Doc.10)

Construction of Finishing works

Figure 3. Proposed Framework.
4.1 Phase I: Pre-Construction phase

**Step 1: Appointment of Consultant**

As previously specified, the consultant appointed for this part of the study was myself.

**Step 2: Briefing session with the clients**

All clients were contacted in the first instance as from the start of June 2017. Since most of them worked, it was possible to meet them after working hours during the week and only on Saturdays during weekends. Hence, meetings were scheduled with each of the clients, and within 2 to 4 meetings, the brainstorming or working session phase was completed with all questions and queries posed answered. All amendments were documented and plans updated accordingly. The building floor area of all residences suffered minor increases in the range of 50 to 90 square feet, which still kept the overall building area to less or equal to 1615 square feet or 150 square metres, Table 1.

**Table 1. Building footprint before and after brainstorming sessions.**

| #    | Residence          | Building footprint (sq.ft.) | Building footprint (sq.ft.) |
|------|-------------------|------------------------------|----------------------------|
| 1    | Pamplemousses – P1 | 1505                         | 1595                       |
| 2    | Pamplemousses – P2 | 1500                         | 1585                       |
| 3    | Riviere Du Rempart – RDR1 | 1495                     | 1550                       |
| 4    | Riviere Du Rempart – RDR2 | 1535                     | 1600                       |
| 5    | Savanne – S1       | 1445                         | 1535                       |
| 6    | Plaine WiHems – PW1 | 1550                         | 1605                       |
| 7    | Plaine WiHems – PW2 | 1490                         | 1580                       |
| 8    | Flacq – F1         | 1350                         | 1420                       |
| 9    | Flacq – F2         | 1398                         | 1450                       |
| 10   | Flacq – F3         | 1445                         | 1500                       |

**Step 3: Updating of plans**

Since the floor area of the buildings was altered, the amended drawings required approval from the respective municipal and district councils before the start of the construction works. The permits were all secured by the end of July 2017. The drawings were updated by a CAD operator, exceptionally appointed for the job for 1 month by myself. The cost of the services provided was Rs18, 000 exclusive of VAT [equivalent to USD 495.50].

**Step 4: Contractor’s matter**

The Contractor was already appointed by the Client based on the quoted labour price, and once the amended drawings completed, the latter was circulated to the Builders for completing the BOQ. The quantity of materials was estimated by the consultant (myself).

It has to be noted that no monies were retained. However, the builder was paid on account of progress and quality of works. Payments for jobs done that were below standard were not entertained in full. Retained monies were released once the re-works were completed to the satisfaction of the Consultant.

**Step 5: Brainstorming session with Contractors**

A first brainstorming session was organised with all the builders, participating in this study. All queries and questions were answered regarding both the research and the framework. Following this session, individual meetings with the Builders were also organised in order to produce/refine the construction methodology, team assigned on the project, list of plant and equipment required, the site organization, how to ensure quality of works through internal quality control, how to uphold health and safety of workers on site at all times during the execution of the works, programme of works and updated BoQ.
4.2 Phase II: Construction phase

The construction process was divided into three parts, part I comprised of the sub-structure while the second phase was on the super-structure and finally the last phase dealt with finishes. However, for each of the phases mentioned above the following steps were applicable.

**Step 1: Before the execution of works**

*Consultant (myself) –* For each site, it was ensured that all materials ordered were in conformity to the required specifications and that a dedicated and competent team of workers were assigned to the job. A daily diary was handed over to the team leader/foreman in which details about daily activities and happenings on site were recorded.

*Contractor –* Ensured that the construction methodology was clear to them and in case of any doubt the consultant was approached for advice. The team of workers had all required competencies to execute the works according to plans, specifications and programme of works. The different tasks were distributed within the group and that all necessary precautions with respect to health and safety were followed.

*Client –* Ensured that all materials, plants and equipment required were already on site prior to starting of the works.

**Step 2: During the execution of works**

*Client –* Ensured that no changes were made during the implementation of the tasks.

*Contractor –* Ensured compliance with the plans and specifications. The team performed expertly with measurable progress. Accidents on sites were either minor ones or were inexistnet. Queries/problems encountered were elucidated. Unforeseen variation works, if any, were documented, priced and executed only after securing approval from both clients and consultant.

*Consultant –* Checked and ensured that the works being executed were according to norms, plans and specifications. The progress of works was gauged using the POW. To ensure good quality control and to avoid reworks due to poor workmanship, visits of the consultant on site was scheduled for two days per week for each site.

**Step 3: After the execution of works**

After completion of the tasks for a specific phase, a general meeting was organised in the presence of all stakeholders (Client, Builders and Consultant) to reflect back on the works completed and the lessons learned documented. The DOs and DON’Ts were recorded to avoid such issues from occurring in the subsequent stages during the construction phase.

5. Results and discussions.

To determine the impact of the proposed framework on the overall performance of the residential projects, the interpretations made as well as the data collected during the observational studies before and after the application of the framework were compared and discussed in this section. The common points between the two set of observational studies are outlined hereunder.

(i) Builders/labour contractors or team of workers were involved in both studies and

(ii) The residential projects satisfied the criteria outlined in section 4.0.

5.1 Cost/Quality performance

With the appointment of a consultant on the project, the client disbursed an additional amount ranging between 3.95 to 4.72 % of the project value. Having the third stakeholder on board, during the construction of residential building projects, was beneficial to the overall running of the venture, especially with the implementation of the proposed framework. Tables 2 and 3 illustrate the benefits drawn.
### Table 2. Cost performance on the application of the proposed framework in figures.

| Contractor Ref. | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 |
|-----------------|----|----|----|----|----|----|----|----|----|-----|
| **Before application of framework** |    |    |    |    |    |    |    |    |    |     |
| Residential area | 1585 | 1450 | 1515 | 1495 | 1545 | 1500 | 1495 | 1525 | 1550 | 1595 |
| Consultant cost USD | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cost of reworks, USD | 4,898.70 | 3,734.55 | 4,214.11 | 5,082.59 | 3,660.89 | 3,245.19 | 4,158.48 | 4,870.36 | 5,269.57 | 4,108.00 |
| Cost of variations, USD | 4,082 | 3,585 | 3,512 | 3,835 | 4,059 | 3,477 | 3,157 | 3,535 | 3,992 | 4,059 |
| Total Cost, USD | 41,639 | 38,192 | 39,358 | 39,927 | 37,219 | 37,629 | 37,503 | 40,874 | 41,411 | 41,688 |
| Final footprint | 1600 | 1550 | 1575 | 1545 | 1605 | 1595 | 1550 | 1595 | 1595 | 1610 |
| Expected cost of project, USD | 32,967 | 33,001 | 32,885 | 32,046 | 30,645 | 32,864 | 31,298 | 33,959 | 33,083 | 33,837 |
| Add. Cost client, USD | 8,671.88 | 5,190.59 | 6,473.13 | 7,880.55 | 6,574.09 | 4,764.77 | 6,205.27 | 6,914.92 | 8,328.30 | 7,851.46 |
| % Add.Cost | 26.3 | 15.7 | 19.7 | 24.6 | 21.5 | 14.5 | 19.8 | 20.4 | 25.2 | 23.2 |
| **After application of framework** |    |    |    |    |    |    |    |    |    |     |
| Residential area | 1595 | 1585 | 1550 | 1600 | 1535 | 1605 | 1580 | 1420 | 1450 | 1500 |
| Consultant cost USD | 1,409.34 | 1,409.34 | 1,409.34 | 1,409.34 | 1,285.71 | 1,409.34 | 1,285.71 | 1,285.71 | 1,409.34 | 1,244.51 |
| Cost of reworks, USD | 657.28 | 391.90 | 702.61 | 336.26 | 1,012.09 | - | 390.66 | 585.16 | 627.40 | 803.57 |
| Cost of variations, USD | - | - | - | - | - | - | - | - | - | - |
| Total Cost, USD | 34,931 | 34,459 | 34,049 | 34,713 | 33,926 | 34,479 | 34,231 | 31,129 | 31,913 | 32,955 |
| Final footprint | 1595 | 1585 | 1550 | 1600 | 1535 | 1605 | 1580 | 1420 | 1450 | 1500 |
| Expected cost of project, USD | 32,864 | 32,658 | 31,937 | 32,967 | 31,628 | 33,070 | 32,555 | 29,258 | 29,876 | 30,907 |
| Add. Cost client, USD | 2,066.62 | 1,801.24 | 2,111.95 | 1,745.60 | 2,297.80 | 1,409.34 | 1,676.37 | 1,870.88 | 2,036.74 | 2,048.08 |
| % Add.Cost | 6.3 | 5.5 | 5.6 | 5.3 | 7.3 | 4.3 | 5.1 | 6.4 | 6.8 | 6.6 |

**Note:** Cost to client, consultant and contractor is in USD. The area is in square feet.
Table 3. Cost performance on the application of proposed framework percentagewise.

| Contractor Ref. | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 |
|-----------------|----|----|----|----|----|----|----|----|----|-----|
| **Before application of the framework** |    |    |    |    |    |    |    |    |    |     |
| % re-works      | 14.9 | 11.3 | 12.8 | 15.9 | 11.9 | 9.9 | 13.3 | 14.3 | 15.9 | 12.1 |
| % variations    | 12.4 | 10.9 | 10.7 | 12.0 | 13.2 | 10.6 | 10.1 | 10.4 | 12.1 | 12.0 |
| % Add Cost      | 26.3 | 15.7 | 19.7 | 24.6 | 21.5 | 14.5 | 19.8 | 20.4 | 25.2 | 23.2 |
| **After application of the framework** |    |    |    |    |    |    |    |    |    |     |
| % reworks       | 2.00 | 1.20 | 2.20 | 1.02 | 3.20 | -   | 1.20 | 2.00 | 2.10 | 2.60 |
| % Variations    | -    | -   | -   | -   | -   | -   | -   | -   | -   | -    |
| % Add Cost      | 6.3  | 5.5  | 6.6  | 5.3  | 7.3  | 4.3  | 5.1  | 6.4  | 6.8  | 6.6  |

5.2 Reworks
Before the application of the proposed framework, the percentage of reworks, due to poor workmanship (unskilled workforce) during the execution of the contract, was observed to be within the range of 9.9 to 15.9%. On applying the framework, the percentage varied between 0 to 3.2%, figure 4, which represented a significant saving to the clients. The drop in the extent of re-works may be attributed to the following:
- Workers followed working sessions before the execution of the works.
- Training, if required, was provided before the start of the works.
- Internal quality control mitigated the effect of poor workmanship.
- External quality control by consultant enhanced quality works.

5.3 Variation works
Variation works ranged between 10.1 to 13.2% before the adoption of the framework. However, the amount of variation works were reduced to 0%, figure 5. The main reasons for such a drastic change are attributed to:
- Clients have a better grasp of what is being constructed regarding the size of the units, position of the units among others before the start of the construction.
- Changes by clients have been reduced to zero due to the intense work was done by the consultant with respect to the above item.
- Working sessions with both clients and consultant have been very beneficial in the sense that the clients were informed of the implications of making changes during the execution of the works.

Figure 4. Cumulative % re-works before and after application of the framework.
Figure 5. Cumulative % variations before and after application of the model.
5.4 Additional cost
Additional cost, incurred by the clients, were mainly due to reworks and variations. Before the adoption of the framework, the additional cost clients had to disburse ranged between 14.5 to 26.3 %. With the application of the new method, the additional cost could not be reduced to 0% but ranged between 4.3 to 7.3 %, figure 6, which represent a significant drop.

![Figure 6. Cumulative % additional cost before and after application of the model.](image)

5.5 Duration of works
All construction sites worked from Monday to Saturday. Working time during workdays was from 7:30 am to 4:30 pm and on Saturdays from 07:30 am until noon. On 84 % of the residential building sites, during the observational study without the implementation of the proposed system, it was found that on Mondays the workforce was reduced to 1/5th of its capacity. Sometimes the whole team would be on leave without prior notification to the clients. Furthermore, when the project is nearing completion, the rate of absenteeism shoots up considerably, and the reason for such hike is attributed to the team has started a new project to ensure continuous work throughout the year.

With the implementation of the proposed framework, the rate of absenteeism was reduced to a minimum. The amount of absent during the first two weeks of the construction phase were similar to projects on which the framework was not applied, however as from week three onwards the rate of absenteeism dropped considerably and by week five workers took leaves with the permission of the leader, which initially was not the case. In certain instances, the workers would talk to the team leader for permissions and not absences. The continuous working sessions and meetings with the construction team not only induced a sense of belonging but also boosted both the productivity as well as the efficiency of the workers. As end result, the overall standard of construction was improved, hence a decrease in the amount of reworks. The works, on the whole, was executed to average industry standard quality and it is expected that the quality will improve if the framework is continuously applied to similar residential building projects.

The role played by the consultant has been very beneficial to the labour contractor/builders/team of workers, however, here it has to be mentioned that the consultant should be very patient with the workers as the learning time for shifting from bad practices to good ones is quite tedious and time-consuming. Close monitoring of works by experienced and skilled workers and or consultant should be encouraged at all times until the skillsets are earned by the less experienced workers. It has to be noted that the dedication of the unskilled workers to learn and the willpower of skilled workers to work towards perfection was recommendable.

Clients, on their part, did not have significant changes implemented during the construction phase, this being mainly due to the several working meetings whereby the proposed constructions were made clear to them. On the whole, the duration of works improved considerably, Table 4.
Table 4. Duration of works, before and after implementation of the framework.

| Contractor Ref. | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 |
|-----------------|----|----|----|----|----|----|----|----|----|----|
| **Before application of the framework** |    |    |    |    |    |    |    |    |    |    |
| Final footprint | 1600 | 1550 | 1575 | 1545 | 1605 | 1595 | 1550 | 1595 | 1595 | 1610 |
| Sub-Structure   |    |    |    |    |    |    |    |    |    |    |
| Setting Out     | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| Excavation      | 1.00 | 0.50 | 0.75 | 1.00 | 1.00 | 0.50 | 0.50 | 1.00 | 1.00 | 1.00 |
| Blinding layer/reinf./Casting | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Blockwall/Columns/casting | 1.50 | 1.25 | 1.25 | 1.50 | 1.50 | 1.50 | 1.25 | 1.25 | 1.50 | 1.50 |
| Engineering fills/compaaction | 1.00 | 1.00 | 1.25 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.25 | 1.50 |
| **Super-Structure** |    |    |    |    |    |    |    |    |    |    |
| Blockwall/ lintels | 3.00 | 2.50 | 3.25 | 3.00 | 2.75 | 2.50 | 2.50 | 3.00 | 3.25 | 3.00 |
| Columns/reinf/casting | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Beams/Reinf/casting | 1.50 | 1.25 | 1.50 | 1.25 | 1.25 | 1.25 | 1.50 | 1.50 | 1.50 | 1.50 |
| **Finishes** |    |    |    |    |    |    |    |    |    |    |
| Rendering to ceiling | 2.00 | 2.25 | 2.50 | 2.00 | 2.00 | 2.00 | 2.25 | 2.25 | 2.00 | 2.50 |
| Internal rendering | 2.00 | 2.00 | 1.75 | 2.00 | 1.75 | 2.00 | 2.00 | 2.00 | 1.75 | 1.75 |
| Screed to floor | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| Duration of reworks | 2.00 | 1.40 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.60 |
| Duration of variation works | 2.00 | 2.00 | 3.00 | 3.00 | 1.50 | 1.50 | 1.50 | 1.25 | 1.50 | 1.50 |
| Total duration | 19.00 | 17.15 | 19.75 | 19.25 | 17.25 | 16.65 | 17.00 | 17.75 | 18.35 | 18.85 |
| **After application of the framework** |    |    |    |    |    |    |    |    |    |    |
| Residential area | 1595 | 1585 | 1550 | 1600 | 1535 | 1605 | 1580 | 1420 | 1450 | 1500 |
| Sub-Structure   |    |    |    |    |    |    |    |    |    |    |
| Setting Out     | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| Excavation      | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Blinding layer/reinf./Casting | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Blockwall/Columns/casting | 1.25 | 1.50 | 1.25 | 1.75 | 1.50 | 2.00 | 1.25 | 1.50 | 1.25 | 2.00 |
| Engg.fills/compaaction | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Surface bed reinf/casting |    |    |    |    |    |    |    |    |    |    |
| Super-Structure |    |    |    |    |    |    |    |    |    |    |
| Blockwall/ lintels | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 |
| Columns/reinf/casting | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Beams/Reinf/casting | 1.25 | 1.25 | 1.00 | 1.25 | 1.25 | 1.00 | 1.50 | 1.25 | 1.25 | 1.50 |
| Slab/reinf/casting |    |    |    |    |    |    |    |    |    |    |
| **Finishes** |    |    |    |    |    |    |    |    |    |    |
| Rendering to ceiling | 1.75 | 1.75 | 1.50 | 2.00 | 2.00 | 1.50 | 1.75 | 1.50 | 1.75 | 2.00 |
| Internal rendering | 1.75 | 2.25 | 2.00 | 2.25 | 2.00 | 2.25 | 2.00 | 2.00 | 2.00 | 2.00 |
| Screed to floor | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| Duration of reworks | 0.50 | 0.25 | 0.50 | 0.25 | 0.40 | 0.00 | 0.50 | 0.25 | 0.25 | 0.25 |
| Duration of variation works | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total duration | 14.0 | 14.5 | 13.7 | 15.0 | 14.6 | 14.2 | 14.5 | 14.0 | 14.0 | 15.2 |

Construction works, on all sites, started by the end of July 2017 and lasted for four months (maximum duration). However, the duration included non-working days such as Sundays and public holidays.

5.6 Health and Safety on residential construction sites
On residential building projects, the risks of accidents are limited, and the types of accidents are classified as minor ones, as listed hereunder.

- Scratches from nails and rebars.
- Cuts from rebars and iron sheets used as hoarding.
- Tripping hazards.
- Falls from ladders or scaffolds (height is less than 3 metres).
- Falling objects (< than 3 metres)
- Electrocution.
- Machine accidents (minor cuts from grinders).
It was noted that the builders did not have or used any Personal Protection Equipment for their safety earlier. However, with the application of the new system they had to have the following PPE at all times on site, namely:

- Hard hats,
- Safety shoes,
- Safety harness when working at heights,
- Safety goggles when cutting bars among others.
- Specific gloves.

All of the workers were initiated to some basic training and precautions with respect to potential hazards that they could be facing on residential construction sites. The practice was through the working session(s) with the consultant.

5.7 Wastage on site
On all of the sites, two helpers were identified within the team to carry out specific tasks during the last 30 minutes of the working time. Their duties consisted of the following:

*Collection of all debris* lying around on the site and disposal of same accordingly. For example, empty cement bags were put in garbage bins; nails were removed from planks and, if usable, were kept, otherwise disposed. Excess of render, mortar, and concrete were collected and used subsequently on site. Since the mortar/render and concrete were in most cases contaminated with soil or other debris the usage was limited to non-structural items such as blinding layer among others.

All sites were kept neat and tidy at all times.

6. Feedbacks collected from stakeholders
After construction of the different dwellings, most of which, were completed in November 2017, a survey was carried out with the various stakeholders and their views on the proposed system collected. Most of the feedbacks collected were positive. However, the generalised negative feedback was unanimous among all stakeholders. "It was tedious and time-consuming for the Clients to understand and decide on the final dimensions of the different units, the position of the units within the residence and the positioning of the residence on the site. For Contractors, they thought they knew how to construct and that the sessions were making them lose time, and they even feared that this would directly entail more delays (not due to works) but they all, after learning and implementing the system, were unanimous that it had been worth spending the time.

6.1 Clients
Clients, all of them, were novices in the construction of residences. The criticism gathered are as listed below.

- "The working sessions were very informative, and by the end of all these sessions I could picture in my head what I was going to construct."
- "If we were not shown in real, the actual sizes of the different units within our proposed residence, definitely during construction we would have requested for changes."
- "A very positive point to us, clients, is that before the start of construction, we had the chance to revise our proposed residence both in terms of unit sizes, the position of units and position of the house on site."
- "We knew that our houses had doors and windows but nowhere were any mention of the type."
- "We appreciated the session on the DOs and DON'Ts during construction, especially when there are financial implications."
- "Contract made between Client and Consultant was very concise and easy to use."
- "Contract made between Clients and Builders or team of workers was very concise and easy to use. We initially thought of having just a paper stating the amount per square feet only."
- "We initially thought that any variation works were already included in the proposed labour fee. However, we were told that we had to pay additional labour fee for any variation works."
- "We were happy to have our residence completed on the agreed time. Initially we thought that there would be delays of one to three months as many of our friends had experienced with their constructions."
“The house was completed within the allocated budget though we were expecting to pay more.”
“We understood what quality of works inferred during our working sessions with the consultant and when we checked our current residence, we could see the number of defects they sustained, however, in our new residence we could hardly find any major ones.”

6.2 Contractors
“We were of the opinion that the proposed framework was a complex system that would hold us back and result in more delays. However, once we were explained the system and started its implementation, we were surprised to see that it was helping us to deliver our projects on time and with the required quality.”
“The working sessions with all of our team members were beneficial to our team as we knew in advance, what to do and how to do it.”
“We did plan our works on a day to day basis, but with the system, we had to plan the works for at least a fortnight and to monitor the tasks on a day to day basis, the advantages of such endeavour was very beneficial to all stakeholders.”
“The internal quality system we implemented increased the quality of our works and resulted in less or negligible defective works.”
“We were taught about how to carry a risk assessment before the start of new work.”
“Encouraging unskilled workers to be trained on the job site was beneficial to our team itself as it boosted our efficiency and productivity.”
“Assessment of variation works was done easily using the proposed rates in the framework.”
“The proposed format for the programme of works is easy to make and follow during construction.”
“With our works being checked by a consultant, we had to ensure that the works were correct before requesting for any approval; this ensured quality works on our side.”
“With the implementation of the system, we could complete the project in lesser time and, to us, our profit margin increased.”
“Completing the project on time, within the client’s budget and with recommendable quality have increased our credibility on the job market. Hence, instead of going for the hunt for new projects we found Clients coming our way to sign us for new ventures, something that is new to us.”

6.3 Consultants
In this specific study, since I was the only consultant, I knew exactly what and how to deal with both Clients and Builders/Contractors. However, it is being recommended that proper training or workshops be organised for potential Consultants.
Working sessions with both clients and contractors were tedious and very demanding. Clients were not able to understand straightforward things related to construction the first time. Contractors, on the other hand, pretended to know the system but while working with them, the contrary was observed.
Helping the builders or team of workers to set up their internal quality system did take some time.
Through the sessions, the workers interested in further learning were quickly identified. The strengths and weaknesses of the team, as well as those of the individual members, were readily acknowledged. Team members with leadership skills were easily identified.

7. Concluding remarks
The proposed framework was applied to ten residential projects with specific attributes, as described in this paper. The impact of the system on the different projects proved to be very successful on many frontiers. The constructions were executed within the expected budgets with very little or insignificant deviations. Duration of projects was as expected and the quality of the resulting works was above average industry standard. Health and safety recommendations were implemented on all of the sites with the result being zero major/fatal accidents. Wastage on site was reduced considerably. Feedbacks collected with the different stakeholders were all positive, which proved that the proposed framework had boosted the performance of these residential building projects.
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