4 DIRECTIONS FOR PRODUCTIVITY IMPROVEMENT

The construction industry has the potential to reach the productivity level found in developed countries. Already public housing construction and a number of commercial and industrial projects have been able to achieve high site productivity. However, more concerted effort is needed from all parties in the construction process if productivity improvement is to be more widespread. The government should set policies and take the lead where necessary to stimulate productivity improvement.

Concurrent Factors to be Considered

The need to raise construction productivity should not be considered and pursued in isolation. It should take the following factors into consideration:

(a) Standardisation vs More Choice/Variety

As quality of life improves, consumers will want more choice and variety. This is clearly seen in residential development where the design variety and choice of finishes and fittings such as tiles, door and window types, roofing materials, sanitary ware, built-in cupboards, etc abound. Clearly, the intention of productivity improvement is not to limit the choice of such components. Standardisation therefore must allow variety as much as possible. The scope for standardisation is greater in structural works such as structural frames and slabs.

To meet the needs for more variety, construction in Europe has moved away from mass production of prefabricated components to ‘lean production’ or ‘flexible industrialisation’. This means smaller volume of standardised components tailor-made to specific projects which optimises the parallel objectives of economic production and variety. Examples are staircases, external wall panels, parapets and balconies which can be specific to a project. The result is high level prefabricated ‘a la carte’ buildings in contrast to ‘set menu’ buildings previously. Prefabrication in Singapore should move in this direction.

(b) Productivity vs Construction Costs

Designs or construction systems which result in higher productivity could be more expensive. The higher costs come from more material usage, higher investment in mechanisation, higher risks due to unfamiliarity with prefabrication, or higher costs due to too many variations in production. The HDB experience in the 80s (Table 4.1) is instructive in considering the cost impact. Slight increase in costs should be acceptable to encourage the industry to move in the direction of labour substitution. However, any major effort to shift work off-site needs discussion with prefabricators to ensure that the economics of production have been adequately considered.

To meet the needs for more variety, construction in Europe has moved away from mass production of prefabricated components to ‘lean production’ or ‘flexible industrialisation’. Prefabrication in Singapore should move in this direction.

Slight increase in costs should be acceptable to encourage the industry to move in the direction of labour substitution.
The Taskforce has found that the issues of aesthetics/variety and cost surfaced often when standardisation or buildability was discussed. It was decided to take at least a qualitative assessment of the implications of buildable design choices. This is summarised in Table 4.2. It can be seen that most features can be used without negative aesthetic or cost impact.

Table 4.1  Comparison of Construction Costs Between Conventional and Industrialised Methods for HDB Projects

<table>
<thead>
<tr>
<th>Methods</th>
<th>Period of Usage</th>
<th>Cost Differential over Conventional Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large Scale Industrialisation</td>
<td>Between 1st quarter 1981 and 3rd quarter 1982</td>
<td>3% increase over conventional methods</td>
</tr>
<tr>
<td>Use of standard prefabricated components (such as refuse chutes, staircases and lightweight partitions)</td>
<td>1985</td>
<td>1.4% increase over conventional methods</td>
</tr>
<tr>
<td>Use of standard prefabricated components together with project specific prefabricated components (such as parapets and external walls)</td>
<td>1999</td>
<td>Range 3-35% increase over conventional methods</td>
</tr>
</tbody>
</table>

Table 4.2  Aesthetic and Cost Implications of Buildable Design Choices

<table>
<thead>
<tr>
<th>Design Choice</th>
<th>Aesthetic Impact</th>
<th>Cost Impact</th>
</tr>
</thead>
</table>
| 1. Less or no beams; flat slab                     | No negative impact  
- in fact, looks better                                                                                       | Structure costs slightly more; but can save floor height, less wall cost; optimise with prestressing |
| 2. Precast staircases                              | Minimum negative impact  
- in fact, better finished; unless many types of staircase matters                                                  | Should save cost but needs sufficient repetition                                                     |
| 3. Precast floor slabs                             | Minimum negative impact  
except joints seen from below; with false ceiling - no problem                                                       | Competitive                                                                                           |
| 4. Wire mesh for slabs and walls                   | No negative impact                                                                                                 | Costs slightly more                                                                                    |
| 5. Regular grids                                   | Can be done for most (80%) of floor layout without negative impact                                                 | Generally save cost                                                                                   |
| 6. Standard Column size                            | No negative impact                                                                                                 | Can save cost if use higher strength concrete on lower floors                                        |
| 7. Prefabricated external walls, parapets, balconies| Can be ugly if too simplistic; however, can be aesthetic - wide variety (shapes, features, finishes) possible in a panel; only requires sufficient repetition - lean production | Cost impact depends on repetition (horizontal and vertical); can be costly if too many types           |
| 8. Internal dry wall                               | No negative impact if joint lines are sealed                                                                       | Generally more costly; mass use can bring cost down                                                  |
| 9. Standard doors and windows                      | Some aesthetic impact                                                                                                | Costs less                                                                                            |
(c) Skilled Workers vs Unskilled Workers

The encouragement of more off-site work will change the skills required on site from craft to more installation or assembly. This will apply more to structural and the large architectural components such as external walls. However, skilled craft workers will still be required for finishing and building services work such as tiling, plastering, plumbing, moulding work and joinery work, etc. Craftwork will become more expensive and such workers will be more highly paid. It will still be necessary to build up a core of skilled workers in these trades.

(d) Local Workers vs Foreign Workers

With a tight manpower market and competition from other economic sectors, it is increasingly difficult to attract local workers to the industry. This is especially so for structural work where the environment is harsher and less safe. However, finishing and building services work should still be promoted to locals as viable career jobs. The increase in renovation and retrofitting, and high quality expectations for finishing and fitting work, will ensure that such workers are well paid. The current trend (Table 4.3) already shows the local worker preference for finishing and building services trades. Foreign workers will predominate the structural and civil engineering trades. Plant operations will also continue to attract locals because these are skilled jobs which pay well.

*Table 4.3 Profile of Local to Foreign Construction Workers in HDB Projects*

<table>
<thead>
<tr>
<th>Building Trade</th>
<th>Local to Foreign Worker Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td>1 : 9</td>
</tr>
<tr>
<td>Architectural</td>
<td></td>
</tr>
<tr>
<td>Fitting</td>
<td>1 : 2</td>
</tr>
<tr>
<td>Finishing</td>
<td>1 : 2.5</td>
</tr>
<tr>
<td>Brickwork and Plastering</td>
<td>1 : 4</td>
</tr>
<tr>
<td>Building Services</td>
<td>1 : 1.5</td>
</tr>
<tr>
<td>Plant</td>
<td>1 : 1</td>
</tr>
</tbody>
</table>

(e) New construction vs retrofitting work

An increasing proportion of Singapore’s construction will be in renovations and retrofitting. Together with HDB’s upgrading programme, this will constitute 12 to 15 percent of total construction work. The potential for productivity improvement is generally less than new construction as new work has to integrate with existing structures.
Productivity Objective

In view of the above, the objective of productivity improvement should be to reduce manpower usage in site construction at reasonable cost while maintaining design variety and high quality work. This objective has 3 components. Firstly, the focus is on improving site productivity which implies design and construction methods that reduces on-site work and/or shifts more work off-site. Secondly, productivity improvement should not result in excessive cost increase which will ultimately pass on to the consumer. Thirdly, productivity improvement has to meet the need for design variety and high quality expectations in Singapore's development.

Long Term Directions

If construction is to achieve the productivity levels in developed countries, long term directions are needed. Productivity levels cannot improve overnight, but systematic policies and promotion will enable the industry to respond and upgrade itself. The long term directions recommended by the taskforce are as follows:

A Development and Promotion of buildable designs

Design is the starting point in any project. As design and construction will still remain predominantly separate functions, developers' awareness and designers' attention to buildable designs will have significant impact on site construction methods and systems used. This is clearly shown in CIDB's study on more than 43 projects (Figure 3.1) in which buildable designs resulted in more efficient construction using less workers.

The development and promotion of buildable designs should proceed on three fronts:

► Public sector projects to adopt buildable designs

The taskforce recommends that public sector projects take the lead as public sector building construction takes up about half the building work in Singapore. This will provide sufficient critical mass to demonstrate the advantages and benefits of buildable designs for various types of buildings. The adoption of buildable designs will be done by setting targets for buildability improvements over a medium term period such as 5 years.

► Develop and propagate buildability technology

The industry is generally not familiar with buildability technology especially prefabrication. Prefabrication requires experience and expertise to address other design considerations such as water leakage and stability of structures. The industry needs to source, adapt and develop, where applicable, technological advancements from abroad to maximise productivity. Where necessary, tests on imported or locally developed systems should be done and recognised by building authorities. Of immediate priority are external wall panels and structural beams. The economies of lean production is also an important area of development. This knowledge should be propagated to professionals and students in tertiary institutions.

The objective of productivity improvement should be to reduce manpower usage in site construction at reasonable cost while maintaining design variety and high quality work.
It is important to educate the private sector on the potential for cost and time savings of buildable designs. The CIDB should conduct studies on projects with buildable designs to ascertain and demonstrate the potential benefits of buildable designs.

Promote more design-and-build projects

The majority of projects will still have designs done separately from construction. However, we are beginning to see some projects where design and construction are integrated. More of these should be promoted. Integrating the design and construction phases will result in greater productivity as construction considerations are taken into account at the design stage.

The taskforce had explored the proposal of a minimum buildable score requirement as a pre-requisite for building plan approval or as a basis for allocation of workers. However, these proposals were considered either too restrictive or difficult to reconcile with the issue of labour savings.

B Development of a core of skilled workers

A productive industry still requires a core of skilled workers in relevant trades even though the level of mechanisation and prefabrication goes up. This core of skilled workers will comprise largely local workers and assimilated foreign workers. The current local workforce is ageing. It is necessary to attract and train a new generation of skilled workers and trade foremen, especially for the craft trades in finishing and building services. The programmes to achieve this will focus on four areas:

Apprenticeship training

Some attempts at apprenticeship were made in the mid eighties but it was not developed further. An apprenticeship scheme should be activated with modifications to suit employer and trainee needs. This programme should involve both main and subcontractors through a joint programme between SCAL and CIDB.

Better status and employment conditions for local workers

It is necessary to enhance the status of local workers so that they can take pride in their employment as construction workers. The SCAL and NTUC are working together to promote better worker welfare.

Continued assimilation of skilled foreign workers

Labour policies should continue to encourage skilled, assimilable, foreign workers to become part of the local workforce. This is especially for the structural and some finishing trades in which it is increasingly difficult to attract locals. The possibility of extending the stay of skilled (but not assimilable) foreign workers beyond 6 years should also be considered.

Expansion of training

Construction training while retaining craft skills such as plastering and tiling should be enlarged to include assembly type skills which will be needed as the level of prefabrication moves up. Skill enhancing courses and foremen training should be introduced as part of continuing training.
C Foreign worker policies which encourage higher productivity

Foreign worker policies should encourage higher productivity by favouring skilled workers and less workers. The current levy differential between skilled and unskilled workers should continue to indicate preference for skilled foreign workers, while recognising that unskilled foreign workers will be needed for certain types of work. Current labour usage figures show that structural trades require a lot more foreign workers than finishing and building services trades. Trades which need more workers should be allowed more foreign workers but perhaps at higher cost.

D Development of subcontractors

The subcontracting segment of the industry needs recognition and development in order to be attractive to the next generation of construction workers. The development of sub-contractors is crucial to worker development and welfare, and productivity and quality standards for the future. The Singapore Contractors Association Limited (SCAL) can play an active role in the development of their subcontractors. SCAL is already considering setting up a voluntary system of recognising their members' subcontractors. CIDB can assist in providing training programmes to help develop the subcontractors.

E Improving construction management

The management upgrading of local firms, professionals and technical personnel need to be given priority. Good construction management is a major contributing factor to achieving high productivity and quality. Effective planning and management of equipment and materials, proper organisation of subcontractors and workers, early preparation of shop details and good housekeeping help to reduce downtimes and wastages and creates a safer and better work environment. The industry should aim to make the high standards of Japanese construction management commonplace.

F Construction automation initiative

Construction in developed countries is leaning towards full or semi-automation in the construction process, although much of it is still in the developmental stage. This should be a long term objective to implement more automated processes as and when the technology is available and affordable. As our contractors get more sophisticated and as more design and build contracts are awarded in the future, the scope for automation is likely to increase. It is recommended that the CIDB and SCAL with the assistance of EDB undertake a more detailed assessment of the long term feasibility of automation. In the meanwhile efforts to promote mechanisation, especially at the subcontractors level should continue.
Productivity Impact

Present data gives an indication of where the Singapore construction industry stands vis-a-vis countries such as Japan and Finland. To reach current productivity levels of Finland will mean a productivity improvement of more than 60 percent. This requires increasing the level of prefabrication from the present 6 percent to the level of 50 percent. If we aim at Japan’s productivity level, this means a 30 percent improvement. This can be achieved in 10 years. The level of prefabrication, however, will need to be in the region of 15 to 20 percent, with a high level of mechanised systems.

The likely reduction of workers for the construction industry if it reaches the productivity levels of Japan or Finland is shown in Table 4.4. These figures are computed based on current construction workload of S$7 to S$8 billion. At Finland’s productivity level, today’s construction workload will require 69,000 workers, a reduction of some 36,000 workers. At Japan’s productivity levels, today’s construction workload will require 83,000 workers, a reduction of 22,000 workers.

Table 4.4 Need for Foreign Workers at Higher Productivity Levels

<table>
<thead>
<tr>
<th>Productivity level</th>
<th>Level of Prefabrication</th>
<th>Total number of workers</th>
<th>Reduction in workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Singapore (current)</td>
<td>6%</td>
<td>105,000</td>
<td>–</td>
</tr>
<tr>
<td>Japan (improvement by 30%)</td>
<td>20-25%</td>
<td>83,000*</td>
<td>22,000</td>
</tr>
<tr>
<td>Finland (improvement by 60%)</td>
<td>40%</td>
<td>69,000*</td>
<td>36,000</td>
</tr>
</tbody>
</table>

*Reductions are computed based on total of 95,000 workers. This excludes 10,000 workers who are deployed in retrofitting works.

The reduction in workers should result in lowering of foreign worker demand by the same magnitude, assuming the local workforce remains unchanged. The industry should aim to achieve Japanese productivity levels.

Programmes for the next 3 years

The taskforce recommends the following programmes for the next 3 years:

(a) Start a major standardisation effort to apply prefabrication and buildability technology to replace labour intensive structural and brick and mortar architectural work. The CIDB and public sector agencies such as HDB, PWD, JTC, MINDEF and PSA should spearhead this effort and set minimum buildable standards for their new projects. Consultations should be held with industry associations and building manufacturers to apply the principles of lean production.

(b) Start a concurrent programme to source, adapt and/or develop prefabrication and buildability technology suitable for Singapore’s construction needs. Among the major areas that should be addressed are:
   • External wall panels and structural beams
   • Lean production technology
The same organisations in (a) should lead this effort together with professional institutions such as the Institution of Engineers, Singapore (IES) and Singapore Institute of Architects (SIA), tertiary institutions (NUS, NTU), the Real Estate Developers Association of Singapore (REAS) and the Singapore Manufacturers Association (SMA). The tertiary institutions should be persuaded to teach buildability technology.

(c) Promote the use of procurement systems which facilitate the integration of design and construction. The public sector should encourage more design-and-build projects or other ways of procurement which will give contractors more responsibility for design. HDB, PWD and JTC should start this effort.

(d) Launch a construction industry apprenticeship scheme to recruit and train a younger generation of skilled workers, especially for finishing and building services trades. This programme will be carried out jointly with SCAL and the larger sub-contracting firms.

(e) Support SCAL in their efforts to recognise their member's subcontractors. CIDB will provide training programmes to help in subcontractor development.

(f) Start a management upgrading programme for local firms, professional and technical personnel through training managers and supervisors and promoting firm upgrading assistance schemes such as the Local Enterprise Technical Assistance Scheme. The upgrading programmes will be carried out by CIDB and tertiary institutions with assistance from the EDB.

(g) Study the long term scope and viability of automation or semi-automation of construction processes. This will be done by CIDB and SCAL, with the assistance of the EDB.

Conclusion

The above programmes will set the course for a more productive construction industry with a lower reliance on foreign workers in the long term. With policies to control entry of foreign workers, concerted and coordinated effort to develop prefabrication and buildability technology, and by making conditions more attractive for locals to join and stay in the industry, we can attain the productivity levels in developed countries in the long term.