Foreword

The Building and Construction Authority's (BCA) Construction Quality Assessment System (CONQUAS) has been widely adopted as the de facto national yardstick for measuring the quality of building projects. Besides setting standards and measuring the level of workmanship through CONQUAS, BCA is developing a series of publications of Good Industry Practices Guide for different trades.

This "Good Industry Practices – Design and Material Selection for Quality – Volume 1" shares with the industry some of the good practices adopted by developers, practitioners and contractors who consistently deliver high quality work through thoughtful design and choice of materials in construction, particularly in residential buildings. These practices are taken from projects that achieved high CONQUAS/Quality Mark scores. The examples in this guide highlight some of these noteworthy projects. While the other guides in the series focus on "doing things right", this guide focuses on "doing the right thing" through careful design choices and materials selection.

This guide is not meant to be a definitive textbook on building design and material selection to achieve high quality. Neither is it the final word on quality, as there will be new materials and methods. To obtain more comprehensive information and guidance, readers should seek advice from professional designers and material suppliers. We gratefully acknowledge the contributions of these practitioners and trust that the industry will find this publication useful in its pursuit of quality excellence. We welcome any contributions from readers that may add to or improve future editions of this guide.

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INTRODUCTION

Since 1999, the Building and Construction Authority (BCA) have produced a series of 9 Good Industry Practices Guides. These guides detail work processes and methods of installation for various finishing trades e.g. ceramic tiling, timber flooring, waterproofing works, etc. If the guidelines are followed closely, one can expect the resultant end product to be a high quality building of workmanship excellence. These guides have been used as reference standards in quality assessments under BCA's CONQUAS or Quality Mark (QM) schemes.

While it is possible to achieve high quality standards by following closely these guides, sometimes the proper design, detailing or choice of material can often reduce the time and effort required during construction to achieve the same or better end result. Some conventional methods, materials or designs may require the employment of more skilled workers to work in difficult circumstances and therefore take a longer time to complete the works. Such skilled workers are invariably in short supply and as projects usually have to be completed within very tight schedules, workmanship quality is often sacrificed.

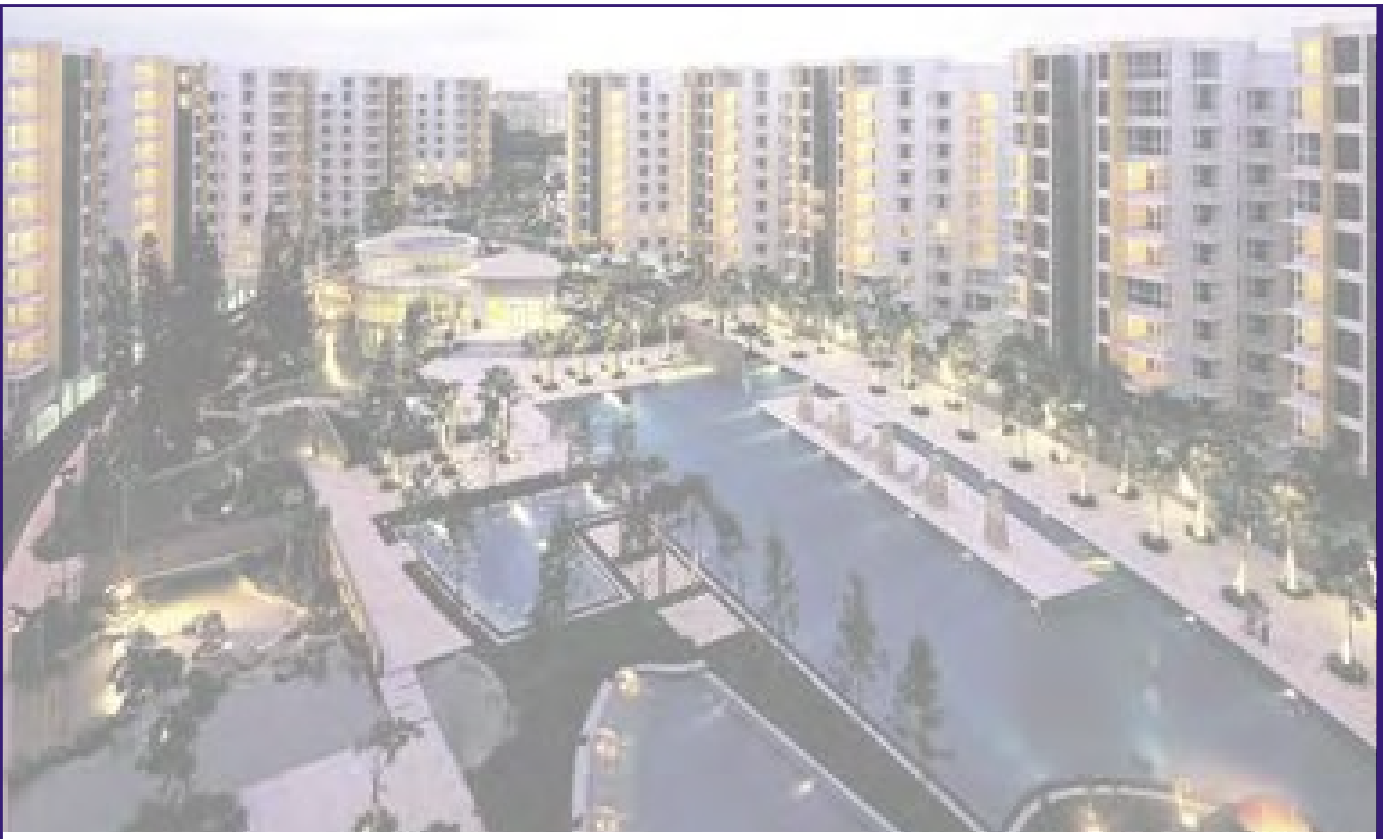
Good design is an integral and essential part of construction. Good design facilitates construction work to be carried out optimally within time and cost constraints. It addresses the following aspects:

- Safety
- Meeting end–user's needs
- Functionality
- Build Quality
- Buildability
- Sustainability
- Aesthetics

To strike a balance in all the aspects and achieve good quality in the final product, plans and specifications should be carefully designed, reviewed at each stage and corrected before construction starts. Overlooking any of these may result in additional time and cost to rectify the works.

This guide attempts to distill many good design practices and material choices observed in various CONQUAS and QM projects that have achieved workmanship quality excellence as reflected in their high CONQUAS/ QM scores. Industry professionals can learn and apply these practices in their projects for better quality achievement. As each building's design objective may be different from another, it may be necessary to be selective or customize the mentioned practices to meet the specific needs of the project. This guide has made comparisons with some designs choices that may be difficult to build or has inherent difficulties in achieving quality. This does not mean such designs cannot be employed. It only means that more time, attention and higher cost may be incurred to achieve the same quality result.

This guide is the first of 2 volumes and focuses on good design choices for workmanship excellence. The subsequent volume will cover other design choices and material selection that impacts quality.



1.0

AN OVERVIEW OF BUILDABLE DESIGN AND QUALITY

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"Buildabilty" is the extent to which the design of a building facilitates ease of construction.

Buildable design often has a direct implication on quality achievement in a project. Projects with better quality performance (as measured by CONQUAS- Construction Quality Assessment System) invariably are also those that had adopted good buildable designs. Examples of such projects, which can be found in I-QUAS (Information on Construction Quality-ref: **www.bca.gov.sg**) include commercial, residential, institutional and mixed developments like The Esparis, Monterey Park, Savannah Park, The Pier, Icon, One Marina and ITE Simei.

The developer, designer and builder each has a significant role towards achieving better buildable design and quality in construction. This chapter illustrates examples of good buildable designs and its contribution to quality.

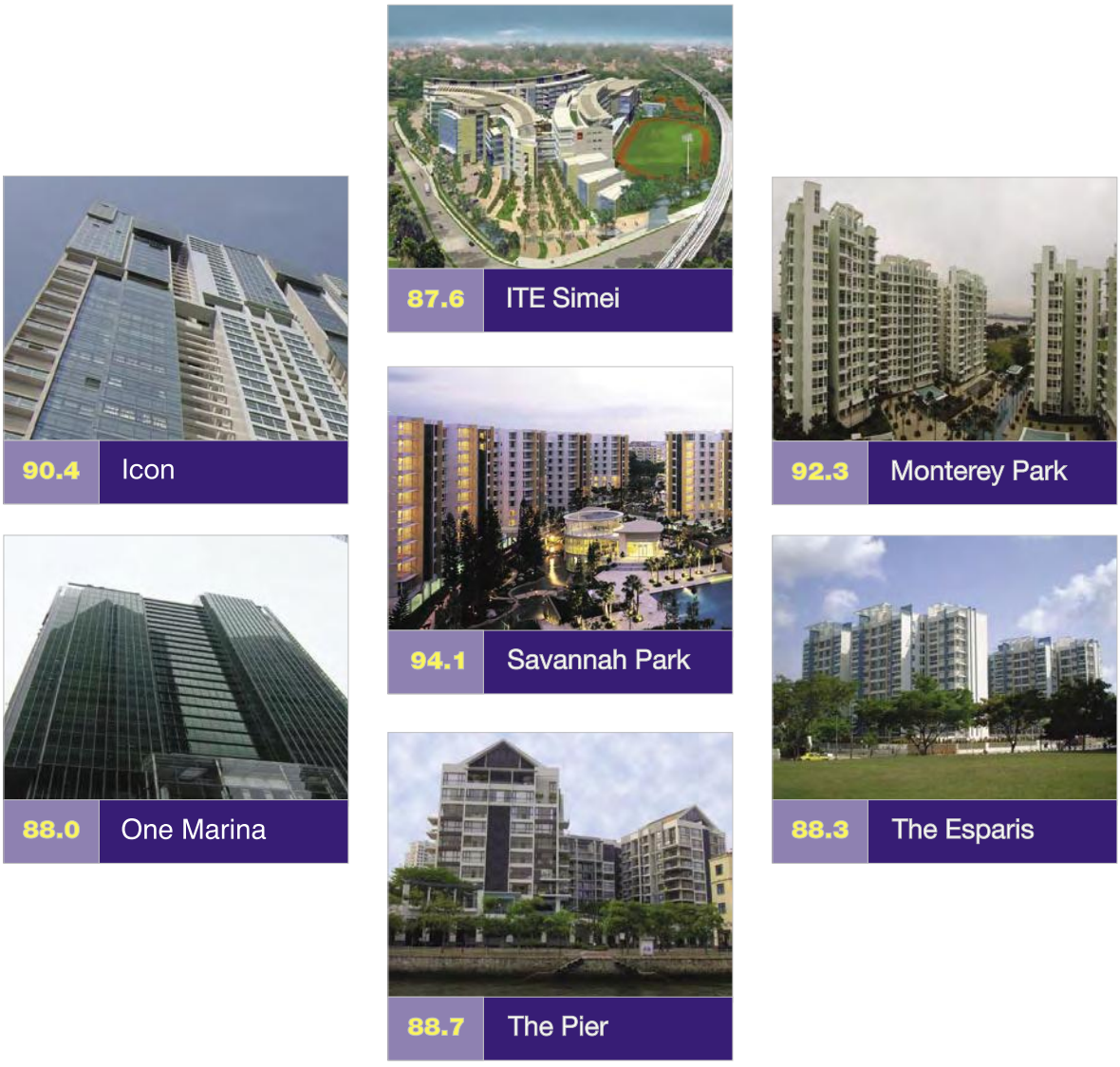


Fig. 1.1 - Examples of projects with good buildable designs and high quality performance scores.

1.1 EXAMPLES OF GOOD BUILDABLE DESIGNS

The following are examples from residential projects that adopted good design concepts such as flat plate slab, curtain wall, drywall partitions, prefabricated bathrooms, screed-less floor, etc. All these buildable systems facilitate ease of construction leading to good quality workmanship.

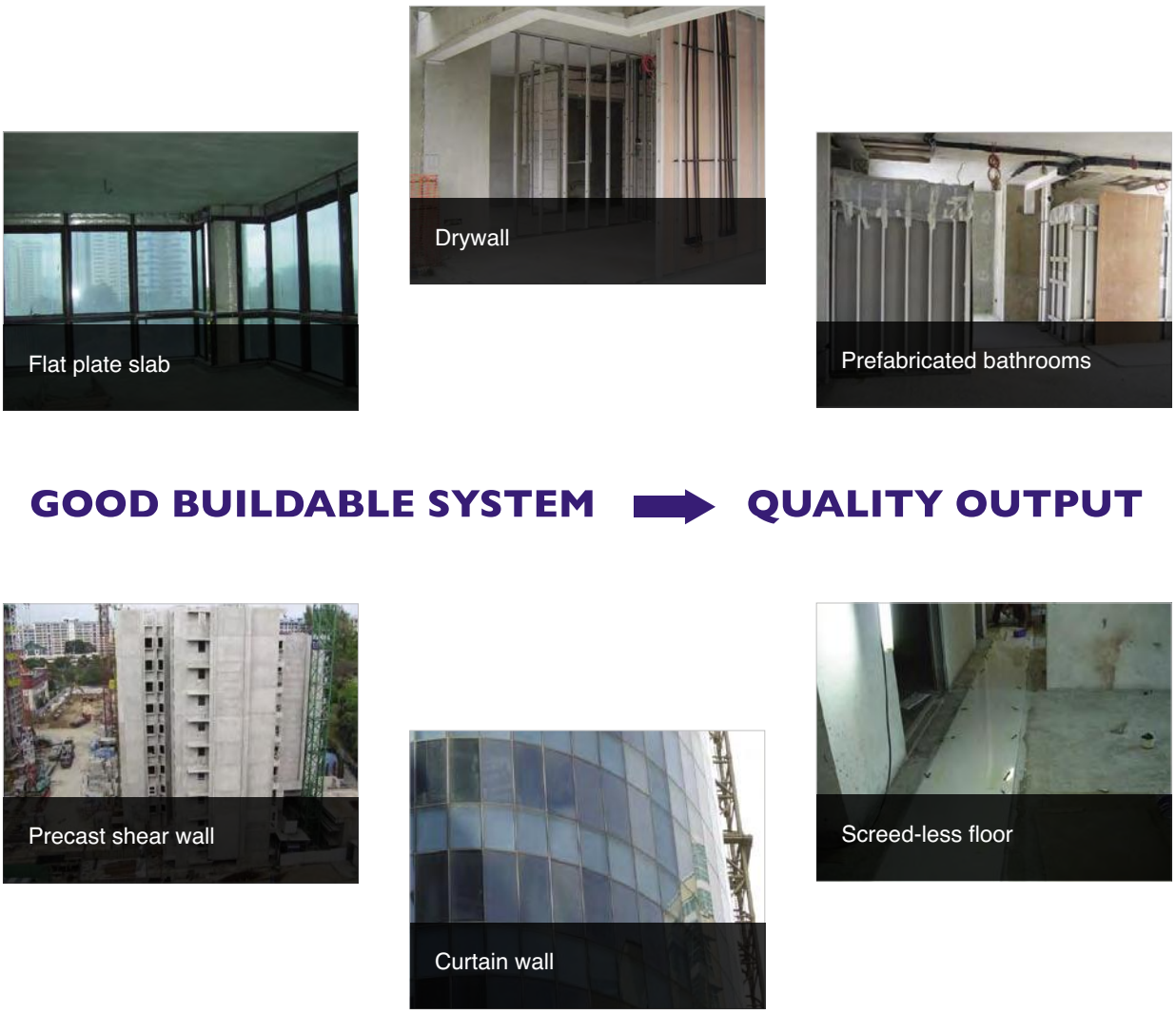


Fig. 1.2 - Buildable systems contribute to efficient and quality construction.

1.0 AN OVERVIEW OF BUILDABLE DESIGN AND QUALITY

1.1.1 Flat plate slab

The floor slab has no intermediate or secondary beams. This improves the construction cycle time and productivity. The quality of the slab surface is also better as there are less joints in the system formwork. The M&E system can be accommodated easily under the slab since there are no intermediate beams causing obstructions.

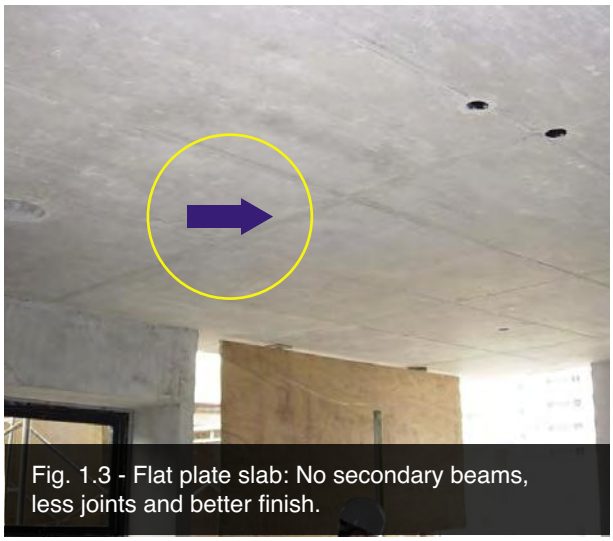


Fig. 1.3 - Flat plate slab: No secondary beams, less joints and better finish.

1.1.2 Drywall partitions

Drywall partitions have many advantages compared to conventional wet trade partitions. Quality finish, speed of construction, ease of installation and reconstruction are the key attractions. See Chapter 5.2 for more details of its features and advantages.

Fig. 1.4 - Drywall partitions: Increasing use in residential building construction.

1.1.3 Prefabricated bathrooms

Bathrooms are prefabricated in a factory and installed on site. This innovative method results in better tolerances and the workmanship is significantly better than conventional bathroom construction. The off-site production often makes the manufacture of the bathroom no longer a critical activity that may affect other construction works on site. The different techniques in production and installation are explained in Chapter 5.1.

Fig. 1.5 - Prefabricated bathrooms: Improved technology for quick installation.

1.1.4 Screed-less flooring

A combination of suitable adhesives and a leveled concrete floor slab makes the system practical. Using this method, screeding, one of the "messy" trade in flooring installation, can be eliminated. Hollowness in flooring, which is caused mainly by incompatibility between substrate and screed, can also be minimized.

Fig. 1.6 - Screed-less flooring installation: Better productivity and quality.

1.1.5 Curtain wall

The fabrication of curtain wall components are carried out in the factory and this reduces site work and allows greater control over component quality. The site operations require only installation works. The process of installation is much faster compared to wet trade methods. Since the method of assembly is a dry process, the required tolerances and workmanship can be controlled closely. When selecting curtain wall system, considerations should be given to sustainability and environmental factors such as using Low-E glass panels.

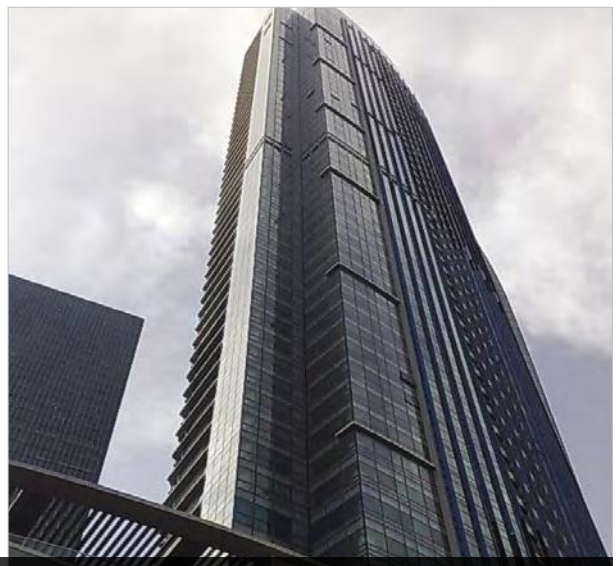


Fig. 1.7- Curtain wall systems: Saves time, better quality facade

Curtain walls

- No scaffolding
- No wet trades
- Less workmanship issues

1.1.6 Modular system walls

The modular system RC (Reinforced Concrete) perimeter walls have less joints and the surfaces are smoother. A thin skim-coat is sufficient to carry the final architectural finish. Construction is neater and productivity higher compared to conventional walls. This system reduces risk of hollowness, surface cracks and unevenness in wall surface, which are usually associated with plastered finish walls.

Fig. 1.8 - Less joints and good surface finish in modular system RC walls

1.1.7 Precast shear walls

The precast shear wall system eliminates infill work like brick or block work and wet trades like plastering. External walls have better water tightness against the elements. Proper design and execution of precast system will give good quality finish surfaces that require minimum preparatory work before painting. Gondolas, instead of scaffolding, can be used to carry out the finishing work; this saves costs and expedites the construction process. Other features and advantages of using precast elements are highlighted in Chapter 4.2.

Fig. 1.9 - External shear walls: Better water - tightness

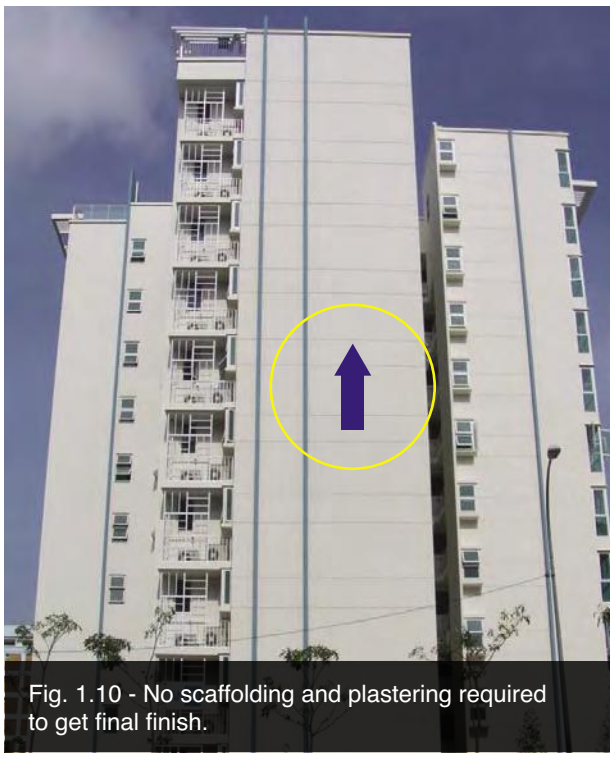


Fig. 1.10 - No scaffolding and plastering required to get final finish.

1.0 AN OVERVIEW OF BUILDABLE DESIGN AND QUALITY

Good buildable design requires careful consideration and planning. It should lead to designs that improve construction processes, ease of construction, reduced dependency on on-site manpower and improved quality. Although the initial cost of construction of buildable designs may be higher than conventional methods in some cases, consideration should be given to its benefits of higher productivity, faster completion time and better build quality.

2.0

INFLUENCE OF LAYOUTS/SHAPES ON QUALITY AND CONSTRUCTABILITY

2.0 INFLUENCE OF LAYOUTS/SHAPES ON QUALITY AND CONSTRUCTABILITY

Straightforward and uncomplicated design layouts and shapes facilitate ease of construction and maintenance, enhance productivity and lead to better quality workmanship. There is reduced need for closer co-ordination between trades and hence less dependency to achieve the desired build quality. This becomes more significant where mass production is involved. This chapter shows some examples of layouts, shapes and details and their influence on quality and constructability.

2.1 ADVANTAGES OF CLEAR-CUT LAYOUT

Layouts of regular shapes and without tight corners facilitate ease of construction. It is easier to achieve the desired workmanship quality in the finishing work.

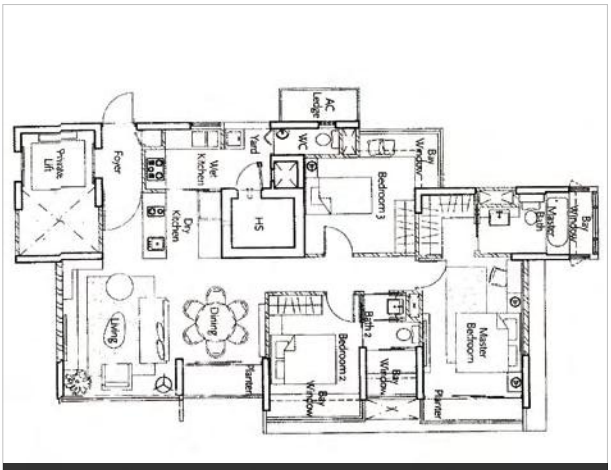


Fig. 2.1 - Regular layout with less tight-corners is easier to build and achieve quality.

2.1.1 Less corners and turns – Ease of architectural works

Layouts with standard room dimensions, less corners and turns facilitate execution of fine architectural finishing works like skirtings, painting, silicon seals, etc. The ease of working over straight surfaces results in consistent and better workmanship. The benefits are enhanced where there is repetition of similar design at every floor.

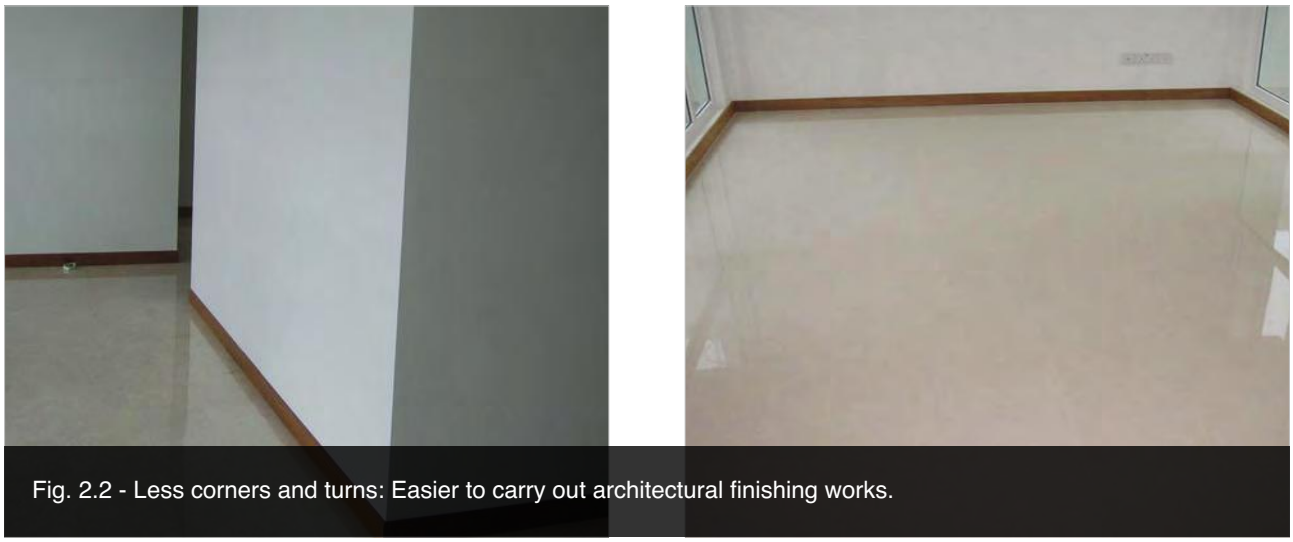


Fig. 2.2 - Less corners and turns: Easier to carry out architectural finishing works.

2.1.2 Regular shapes suit prefabricated components

Regular shapes that are used repeatedly generally facilitate prefabricated components like curtain-walls, full height windows and drywall partitions to be used. Such factory made components have better dimensional accuracy and assembly tolerances can be better controlled during erection. This leads to considerable reduction in site manpower and better quality output.

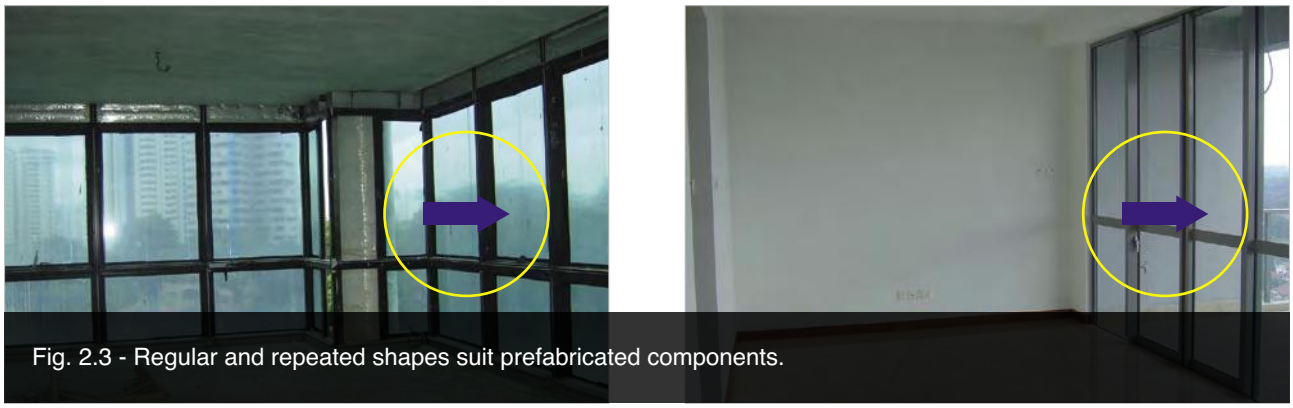


Fig. 2.3 - Regular and repeated shapes suit prefabricated components.

2.2 QUALITY AND CONSTRUCTABILITY CHALLENGES OF CREATIVE SHAPES AND LAYOUTS IN INTERNAL FINISHES

Creative layouts (see Fig. 2.4) generally have more turns and joints. It poses a greater challenge to complete the architectural works in internal finishes with the desired quality. More thought and attention need to be paid to interfacing details, where one trade interfaces with another e.g. joining of marble and timber floor, termination of wet and dry areas, etc. In addition, fine architectural works like skirting installation, silicone application to gaps and fillings, need to be executed carefully within the constraints of the unique shape or layout. In many cases, using traditional wet trades that involve intricate manual cutting of materials to suit the shape or layout may make it more difficult to achieve workmanship quality in addition to slowing the progress of the works.

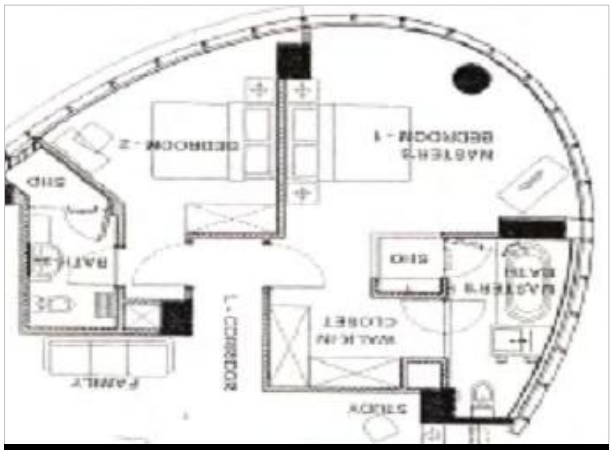


Fig. 2.4 - Creative shapes and layouts : A challenge in finishing fine architectural details.

This has become more significant in residential properties where end-users' expectations are higher. Furthermore, more combination of material finishes and fittings are involved in residential buildings than commerical buildings. Hence clear-cut layouts, precise detailing and right sequence of execution are key factors to achieve desired quality in internal finishes.

2.0 INFLUENCE OF LAYOUTS/SHAPES ON QUALITY AND CONSTRUCTABILITY

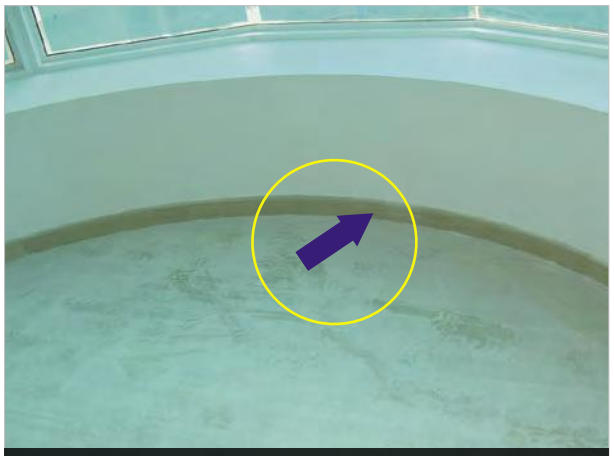


Fig. 2.5 - More attention/skill needed to get final shape and finish.

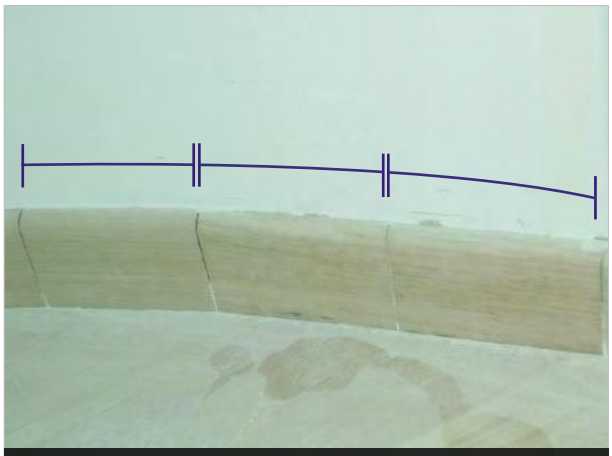


Fig. 2.6 - Too many skirting pieces/joints to get the required profile.

Fig. 2.7 - Small recesses: Difficult to carry out works like skirting, etc.

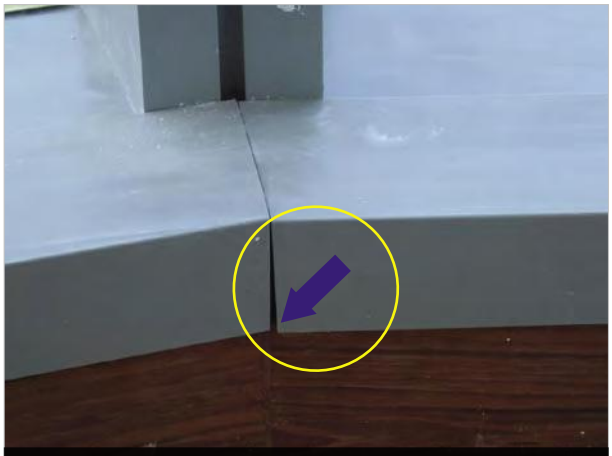


Fig. 2.8 - Protrusions in aluminium capping due to too many jointing segments.

Fig. 2.9 - Circular columns with masonry finishes require more preparation time.

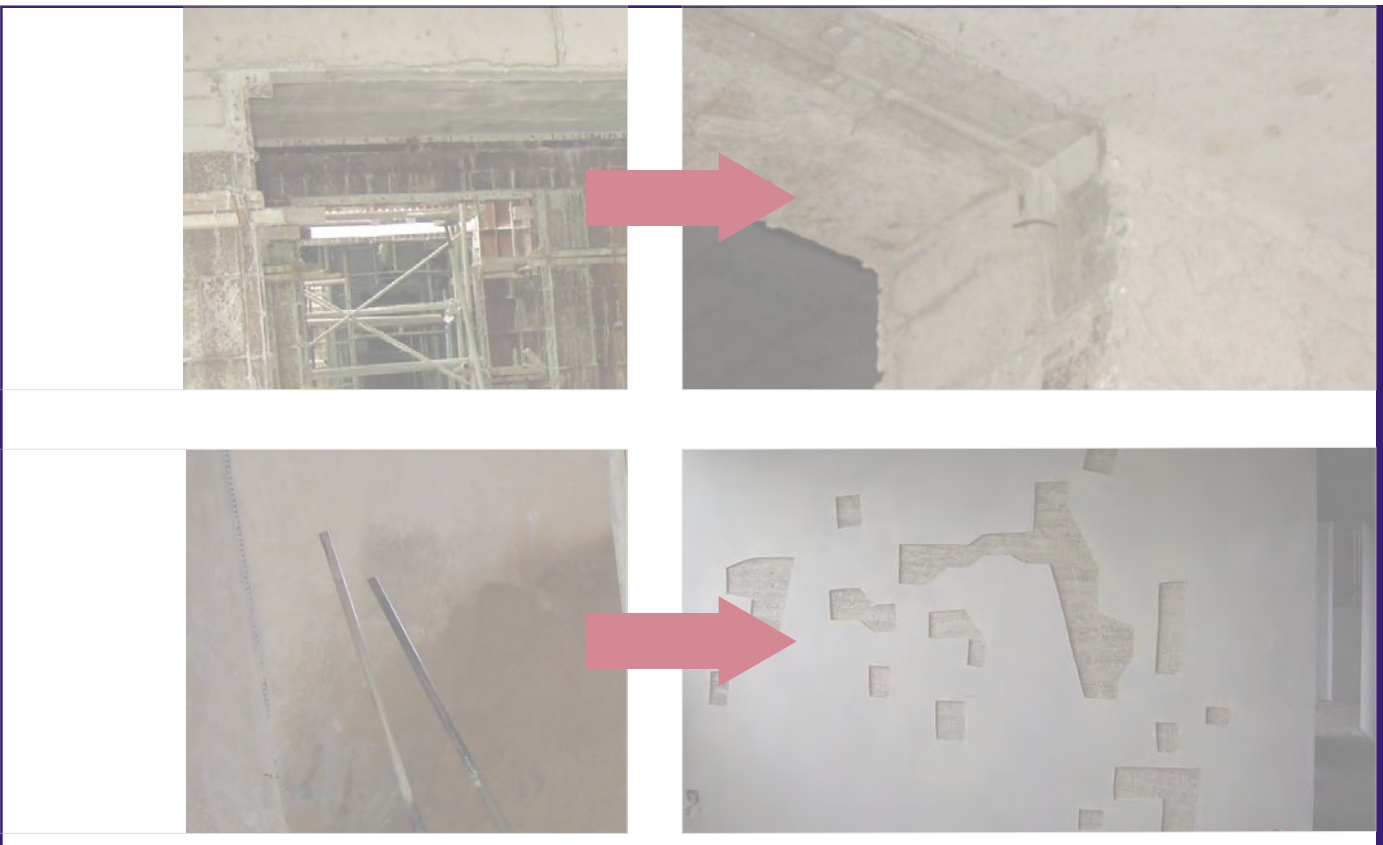
Fig.2.10 - Skirting requires many small segments to form curve.

2.0 INFLUENCE OF LAYOUTS/SHAPES ON QUALITY AND CONSTRUCTABILITY

Fig. 2.11 - Circular column abuts wall: Jointing line is a challenge to finish.

Fig.2.12- Marble needs to be cut manually to suit profile.

The above examples are not meant to discourage professionals from creative designs. The emphasis here is to highlight the challenges posed by creative shapes and layouts and its impact on quality and constructability, particularly where a project has a large number of units which needs to be completed within a limited time frame. In addition, workers with the right training and skills are needed to carry out the fine architectural finishing works. Apart from employing workers with the appropriate skills, the builder also needs to carefully organize and sequence the works so as not to impact construction progress and its quality.



3.0

QUALITY ISSUES IN CONVENTIONAL METHODS & MATERIALS

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Conventional designs that comprise beams, columns, brick/block infills and plastering have inherent inefficiencies during construction. Brick/block wall infills are labour-intensive and cement-sand plastering, a wet process, is often messy and requires more preparatory work. There are also constraints in concealing and routing M&E services. Apart from using more intensive manpower and longer construction duration, there are some inherent difficulties in achieving high quality. Some examples of the challenges posed by such conventional design and materials are highlighted in this chapter.

3.1 CONSEQUENCES IN CHOICE OF INTERNAL FINISHES

Fig. 3.1 - Choice of methods and materials affect workmanship quality.

3.0 QUALITY ISSUES IN CONVENTIONAL METHODS & MATERIALS

3.1.1 Traditional formwork system: More joints and poor surface finish

Traditional formwork system has more connections and joints and it requires more manpower to erect, maintain and dismantle. During erection, close monitoring and supervision is needed to achieve the desired workmanship quality of the finished concrete. If the formwork is not erected properly, the end product would not be satisfactory. Often this means another layer of thick plaster is required to cover the uneven concrete surface.

Fig. 3.2 - Traditional formwork system: More housekeeping.

Fig. 3.3 - Poor concrete surfaces: Thicker plaster is required.

3.1.2 Restricted M&E services run

Many services in a building e.g. electrical, ACMV and sanitary plumbing, etc are concealed under slabs or covered by false ceiling. If there are too many internal beams, especially non-shallow beams, it may be difficult to locate such services under floor slabs. This may restrict the height of false ceilings or the floor storey height may need to be increased to accommodate such services.

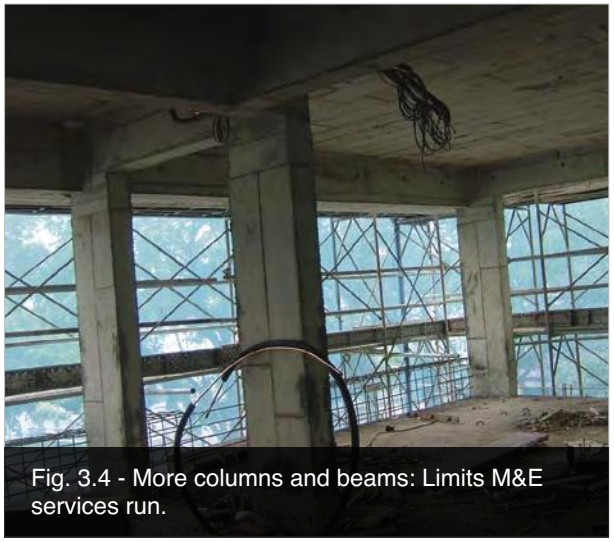


Fig. 3.4 - More columns and beams: Limits M&E services run.

Fig. 3.5 - Internal beams restrict height of false ceiling.

3.1.3 More turns and corners

The width of RC column may be different from the width of the brickwall laid against it, especially in internal partitions, e.g. a 200mm wide column and 100mm thick brickwall. In such situations, an offset of 100mm will appear wherever an RC column adjoins brickwork resulting in a non-flush surface with many corners and returns. There will be greater difficulty in completing the architectural finishing works like plastering, skirtings, architraves, etc.

Fig. 3.6 - The offset of RC and brickwork creates more turns and corners.

Fig. 3.7 - More precise work required for turns and corners.

3.1.4 Additional treatment to joint between two different materials

At the joint interface between different materials e.g. RC and brickwork, special treatment like metal lathing is required to ensure there is proper bond and to prevent cracking of plaster wall at the joint. The additional number of joints increase the time and cost of construction.

Fig. 3.8 - Providing metal lath on each RC and brick joint.

3.2 CONSEQUENCES IN CHOICE OF EXTERNAL FINISHES

Brick and RC Joints: Need additional treatment.

Bulged RC surface: Require thick plaster.

Scaffolding: More housekeeping and longer construction period.

Thick plaster: Possible waviness.

Fig. 3.9 - Common issues in conventional methods.

3.0 QUALITY ISSUES IN CONVENTIONAL METHODS & MATERIALS

3.2.1 Scaffolding tieback holes

To carry out plastering, scaffolding is necessary. The tie back holes used for securing scaffolding can be patched and re-painted only after the scaffold is dismantled. This is to be carried out via gondolas. Due to the different stages of operation, patchiness or uneven finishing on the surface is inevitable on the external wall surfaces.

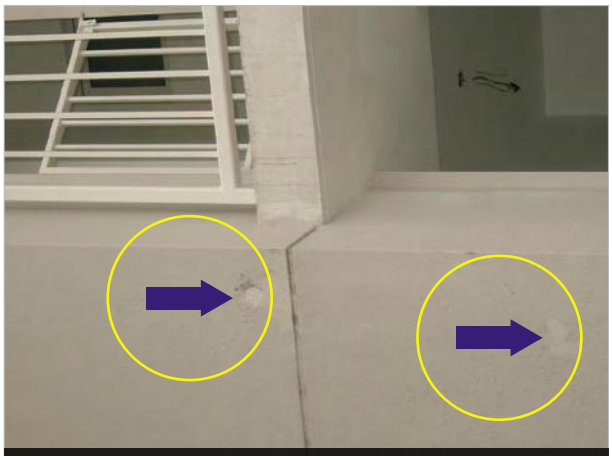


Fig. 3.10 - Scaffolding tie-back holes on facade plastering.

3.2.2 Possible cracks and hollow plastering

Depending on the background substrate, plastering operations are usually 2 or 3 coats work and may comprise a spatter-dash, base or scratch coat and final skim-coat. Proper curing is also required between coats. This affects the overall progress. Besides, if the plaster thickness exceeds the allowable thickness, there is possibility of defects like cracks and hollowness appearing on the surface due to shrinkage of mortar.

Fig. 3.11 - Surface cracks and hollowness appear when plaster is too thick.

3.2.3 Additional waterproofing treatment on joints

For external surface at RC and brick joints, besides laying metal lath, a layer of waterproofing treatment is required to ensure water tightness. Failure to execute these measures properly may result in defects such as cracks and seepages. All these measures are needed to ensure quality in construction and will add to construction time and costs.

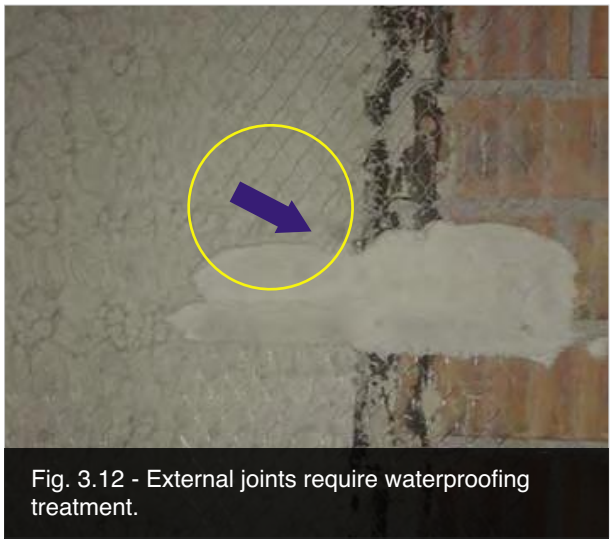


Fig. 3.12 - External joints require waterproofing treatment.

Fig.3.13 - Potential water seepage if joints are not treated properly.

3.2.4 Housekeeping and longer construction period

Scaffolding, and wet trades like brickwork and plastering evidently require more housekeeping effort. More time is required to erect and dismantle scaffolding. This may hinder other concurrent activities and lead to longer construction period.

Fig. 3.14 - More housekeeping is required for scaffolding and wet trades.

Although adopting conventional methods and materials may lead to lower construction costs in some cases, the majority of wet trades pose inherent difficulties in achieving quality construction compared to buildable dry construction. In its place, good buildable design systems that facilitate ease of construction, depend less on-site labour, improve productivity and quality should be considered. These are considered in the following chapters.

4.0

QUALITY FEATURES IN STRUCTURAL ELEMENTS

4.0 QUALITY FEATURES IN STRUCTURAL ELEMENTS

4.1 STEEL STRUCTURES

The physical properties of steel e.g. its durability, flexibility and strength, lend itself to many varied uses, one of which is in construction. The choice of structural steelwork system as an alternative to reinforced concrete structures has many advantages. Steel can be easily formed and joined and its strength to weight ratio is the highest among common building materials. This makes it lightweight and yet strong as compared to concrete structures. Steel can also be recycled and is a good alternative building material that contributes to sustainable construction. The following section highlights the benefits of using steel and its contribution to building quality.

Fig. 4.1 - Steel's durability, flexibility and strength lend itself to use in construction projects.

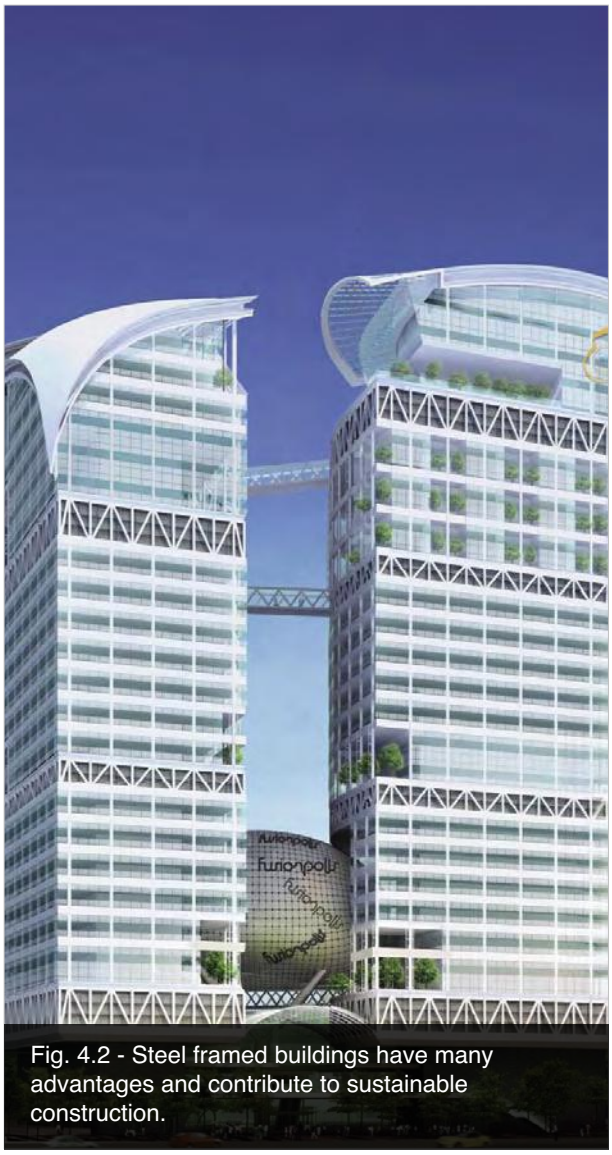


Fig. 4.2 - Steel framed buildings have many advantages and contribute to sustainable construction.

4.1.1 Buildings with accurate tolerances

Steel is dimensionally more stable, unlike other materials that shrink, expand, warp and twist with age. This leads to less settlement cracks or squeaking floors that require costly repairs. Steel buildings can be built with better tolerances and quality and are longer lasting.

Fig. 4.3- Steel is strong, lightweight and buildings can be built with better tolerances.

4.1.2 Architectural aesthetics

The use of steel structures permits designers to experiment with many architectural forms and artistic expressions which are more difficult to build in conventional concrete framed structures. With steel, more challenging and creative designs can now be considered leading to buildings that are aesthetically distinctive and of high build quality.

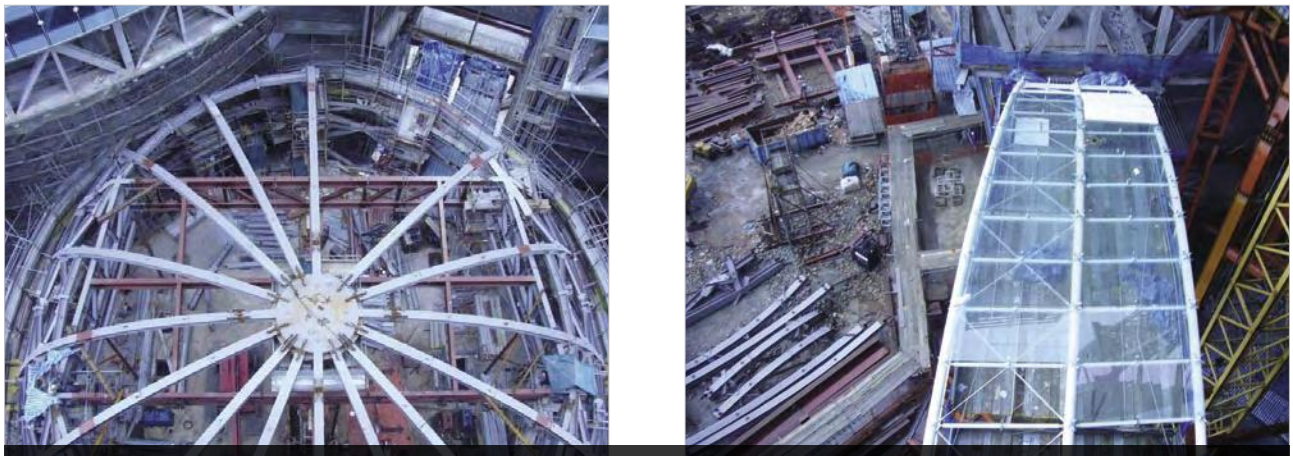


Fig. 4.4 - Complicated structures using steel: A dome shaped auditorium (left) and curved skylight entrance (right).

4.1.3 Quality standards for steel buildings

Stringent requirements are imposed to ensure quality in steelwork construction. Though there can be no meaningful comparison between standards for steel and reinforced concrete construction, the tolerance requirements in CONQUAS are higher for the former. These result in buildings built to more exact requirements and hence better build quality.

Detailed requirements on quality assurance for steelwork, especially for welding, bolting and protection, are based on established international or national standards e.g. the National Productivity & Quality Specifications (NPQS), British National Steelwork Specifications, etc. To ensure quality construction, the stringent requirements are required to be met during fabrication and installation.

Fig. 4.5 - Steel structure office building with curtain wall envelope: More space without obstructive internal columns and beams.

Fig. 4.6 - Quality internal finishing can be achieved in a steel structure building.

• *Quality checks in steel construction*

The images below show typical inspections carried out during fabrication and installation of steel structures.

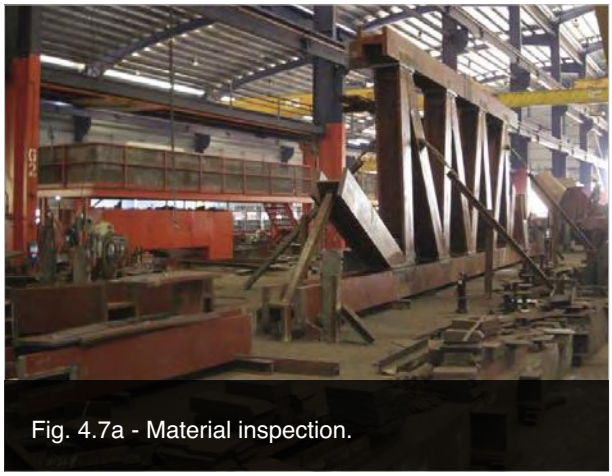


Fig. 4.7a - Material inspection.

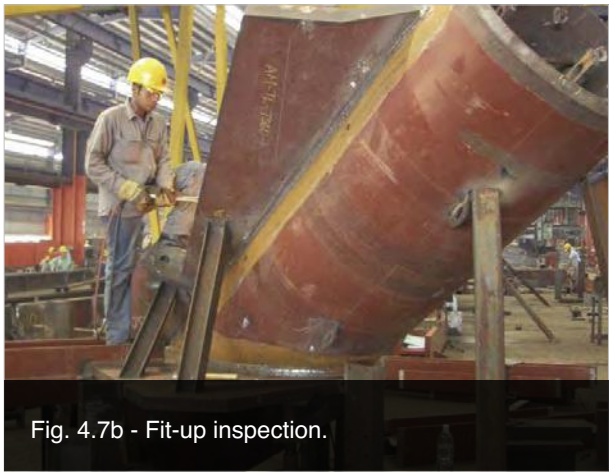


Fig. 4.7b - Fit-up inspection.

Fig. 4.7c - Welding inspection.

Fig. 4.7d - Dimension checks.

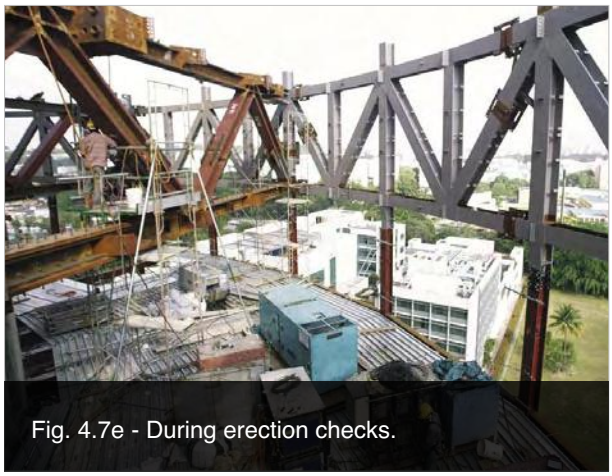


Fig. 4.7e - During erection checks.

Fig. 4.7f - Post erection checks.

Fig. 4.7 - Stringent process checks during fabrication and installation ensure safety and quality in structural steelwork.

4.1.4 Faster construction

Structural steel is lighter than other framing materials. This leads to less heavy foundations which reduces both the time and cost of construction. Productivity is therefore improved and projects can be completed faster.

Another example is the use of metal decking for floor construction. Once the steel framings are in place, installation of metal decking can be completed rapidly. Reinforcement design for such slab is simple and straightforward, and prefabricated reinforcement can be used. As a result, the works can be completed earlier and there is better assurance of concrete quality because of the system of construction.

Fig. 4.8 - Metal decking floor: Faster construction and better concrete quality.

4.1.5 Dry and clean construction

Steelwork enhances productivity because of its predominantly dry construction method. External wall cladding systems (aluminium and glass) are used in conjunction with steelwork and this contributes to rapid construction progress. The stringent tolerances specified for steel framing and cladding systems contribute to good quality finishing.

Scaffolding can be avoided as installation of external wall systems can be carried out by tower cranes and maximizing its use. This scaffold-free method saves on construction costs, makes the site tidier and reduces housekeeping efforts on site.

Fig 4.9 - Scaffold free construction saves time and costs and is less cluttered.

4.1.6 An example of steel structure construction process

A case example of a commercial project employing steel structure construction is Fusionopolis. It comprises 3 uniquely designed steel structure towers each 24 storeys high. The major construction works were completed within 25 months.

The fabrication of the steelwork is done offsite at factory locations where there is skilled labour and the environment and systems are well controlled and conducive for quality output. This is an essential consideration when deciding on the use of steel in design or the choice of steel fabricators.

Flexibility in design and the construction method allow many activities to be carried out concurrently e.g. erection of trusses, metal deck flooring, curtain wall installation and other finishing work, etc, and this leads to faster completion of the project.

FUSIONOPOLIS – PROJECT PROGRESS

Fig. 4.10a
2nd month: Core wall construction.

Fig. 4.10b
4th month: Core wall construction.

Fig. 4.10c
7th Month: Core wall and steelwork framing.

Fig. 4.10d
11th Month: Core wall and steelwork framing.

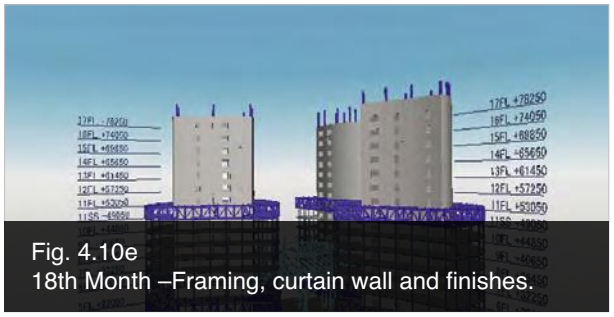


Fig. 4.10e
18th Month –Framing, curtain wall and finishes.

Fig. 4.10f
23rd Month- Curtain wall and finishes.

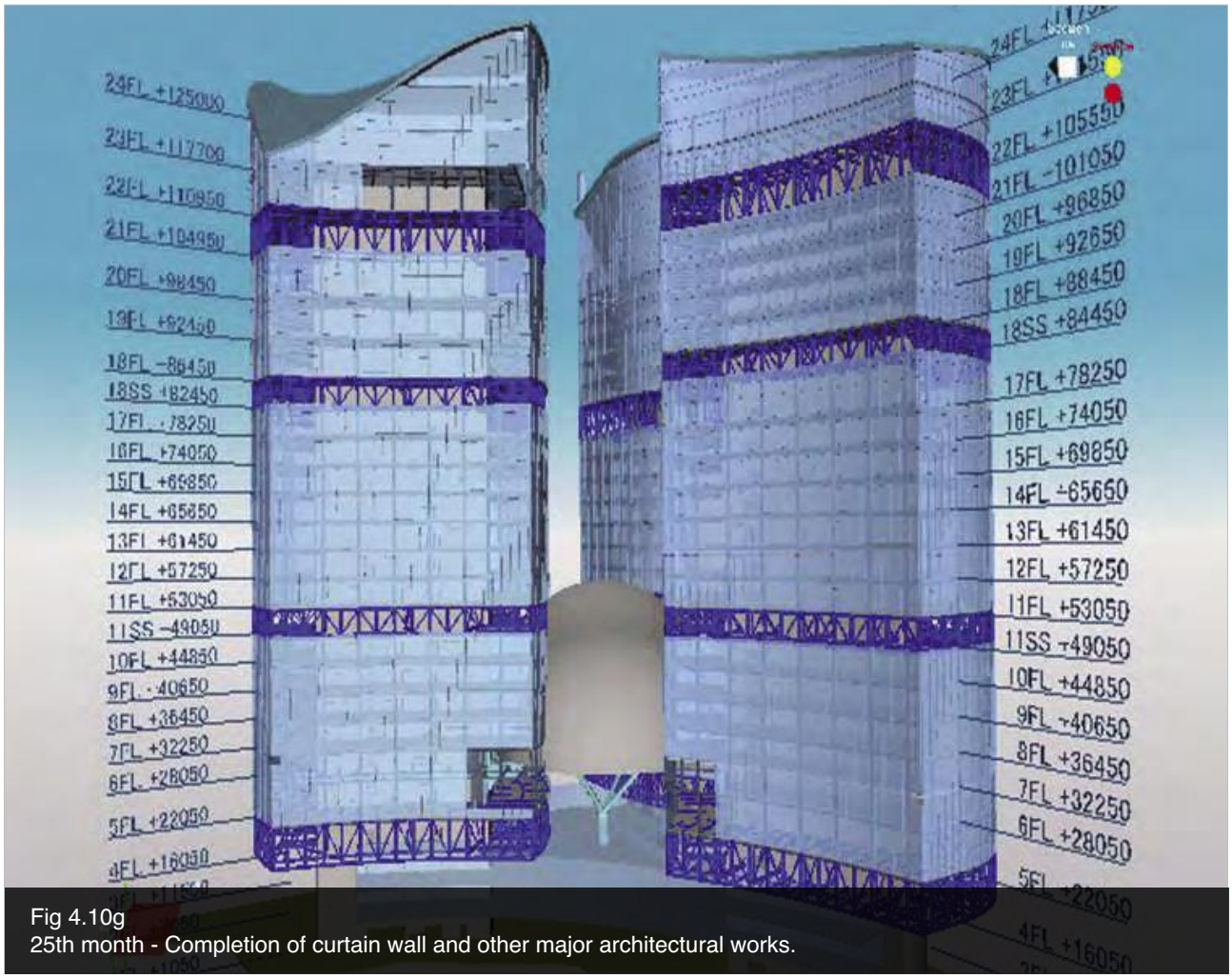


Fig 4.10g
25th month - Completion of curtain wall and other major architectural works.

4.1.7 Challenges in structural steelwork

While there are many advantages in choosing structural steelwork systems, there are also issues particular to steelwork that need to be considered. The safe erection of structural steelwork requires concerted effort by many parties during its fabrication and installation. Instances of poor quality welds and other shortcomings if not detected and rectified early can compromise structural safety. This can lead to serious consequences especially in long span structures.

Proper fabrication and installation require specialized knowledge, appropriate equipment and resources and a comprehensive inspection and testing regime. To enhance safety of the installation, the steelworks should be carried out by accredited steel fabricators, checked by qualified site supervisors and tested by Independent Testing Agencies.

It is necessary to give attention to fire and corrosion protection measures as steelworks exhibit particular vulnerability in these aspects. The local fire safety standards and codes should be complied with. Finally, the higher cost of steelworks construction should be balanced against the expected benefits.

4.0 QUALITY FEATURES IN STRUCTURAL ELEMENTS
4.2 PRECAST CONCRETE ELEMENTS

Precast concrete technology is widely used in the industry to support buildability and improve construction productivity. Such technology also results in better quality workmanship as the precast elements are manufactured under controlled factory conditions before its installation at site. BCA has many publications that provide information on good practices for precasting e.g. 'Structural Precast Concrete Handbook', 'Buildable Solutions for Landed Residential Development' and 'Buildable Solutions for High-Rise Residential Development'. This section highlights the better workmanship quality that can be achieved when precast technology is integrated in the design of the building.

Fig. 4.11 - Precast technology is integrated in the design to improve quality.

4.2.1 Dimensional accuracy

Precast concrete elements achieve superior dimensional tolerances and finished concrete surfaces compared to cast in-situ concrete. This is largely due to the favourable environment in factories where these elements are produced and the stringent quality control measures taken to meet specified or national standards during production.

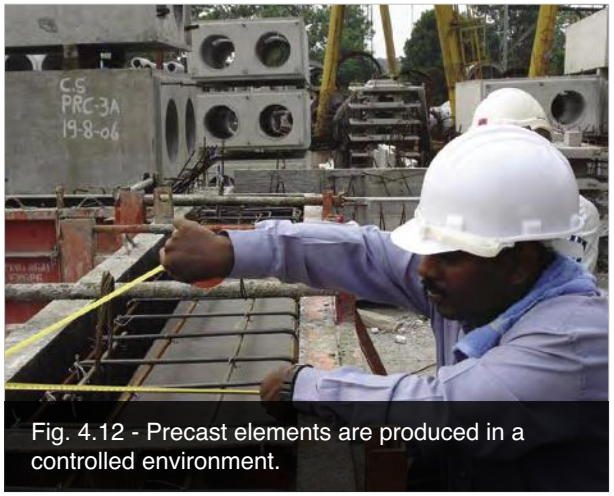


Fig. 4.12 - Precast elements are produced in a controlled environment.

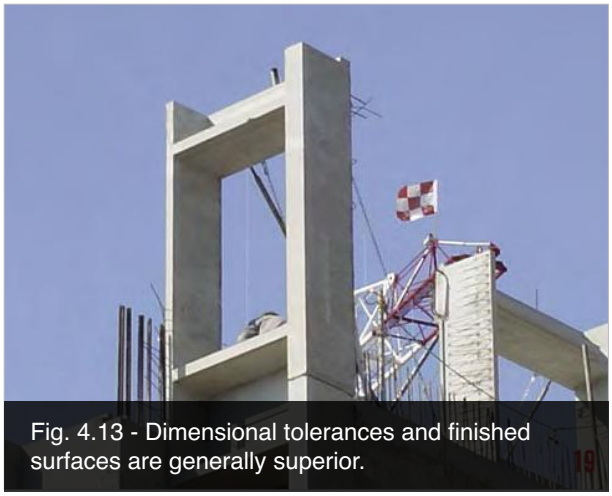


Fig. 4.13 - Dimensional tolerances and finished surfaces are generally superior.

Fig. 4.14 - Window frame installed by dry method using backer rod and sealant.

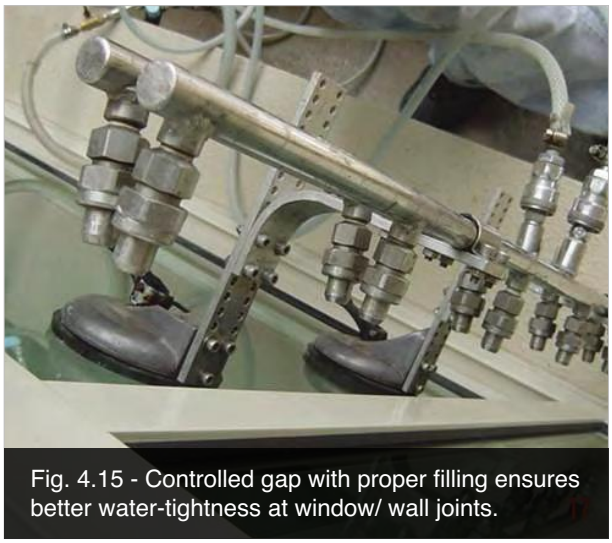


Fig. 4.15 - Controlled gap with proper filling ensures better water-tightness at window/ wall joints.

In traditional brickwork construction, it is a challenge to ensure consistency in forming openings for windows and door frames. Any excessive gaps or improper filling of such gaps may lead to water seepage at the frame and wall joints.

Fig. 4.16 - Difficult to ensure accurate openings with on-site operations.

Fig. 4.17 - Improper filling may lead to water seepage at frame/wall joints.

4.2.2 Better quality critical elements

Precasting is often the solution to quality problems when there are difficulties in executing the particular type of work in-situ. Staircases, refuse chutes and lift walls are examples where formwork, rebar placement and provisions for openings often pose considerable challenges leading to grout loss, inconsistent joints, surface damages and imperfections. Using pre-cast elements for these components, such defects can be reduced.

Fig. 4.18 - Precast staircases: Better dimensional accuracy and quality finish.

4.2.3 Better quality architectural elements

Precast architectural elements such as facades, fascia and gable end walls, parapets, sunshades, secondary roofing panels, bay windows, etc can be used instead of wet in-situ works to achieve correct dimensional tolerances and better quality finish.

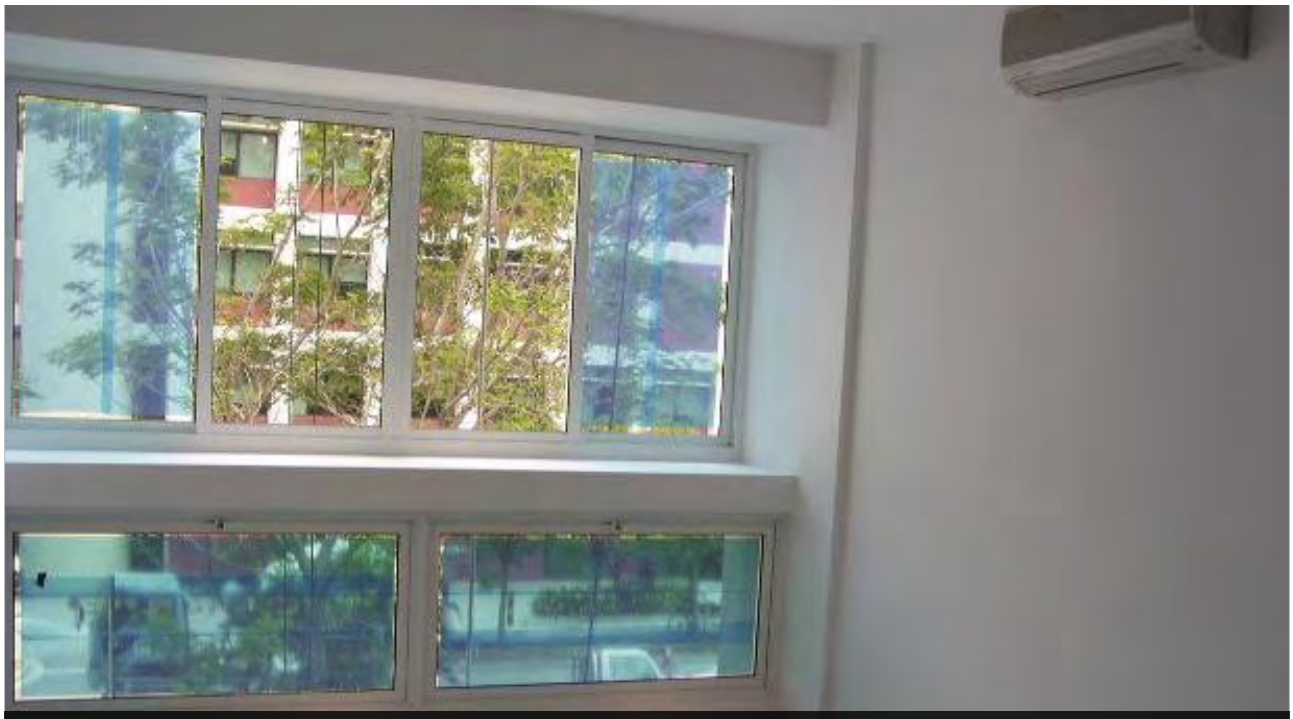


Fig. 4.19 - Architectural precast elements reduce wet works and enhance finish quality.

4.2.4 All-in-one components

In total precast concrete systems, architectural elements can also perform their structural functions. It therefore reduces the number of construction operations and trades. Combining architectural and structural members lead to better organized design and construction. The following precast elements can be combined for greater efficiency and quality:

- Columns
- Shear wall
- Facade walls
- Air-conditioning ledge
- Sun shades
- Bay window
- Beams
- Planter box
- Pipe-duct
- Staircase
- Household shelter
- Refuse chute

Fig. 4.20 - Total precast system results in better build quality building.

4.2.5 Design flexibility

Precast components can be custom made to match design requirements. Complex shapes, sizes and specific technical requirements can be easily fabricated in precast plant. Without such prefabrication, complex designs may be difficult to build or the desired quality hard to achieve on-site using conventional construction. Precasting allows greater design flexibility and repeated use of similar shapes and sizes lead to better economy.

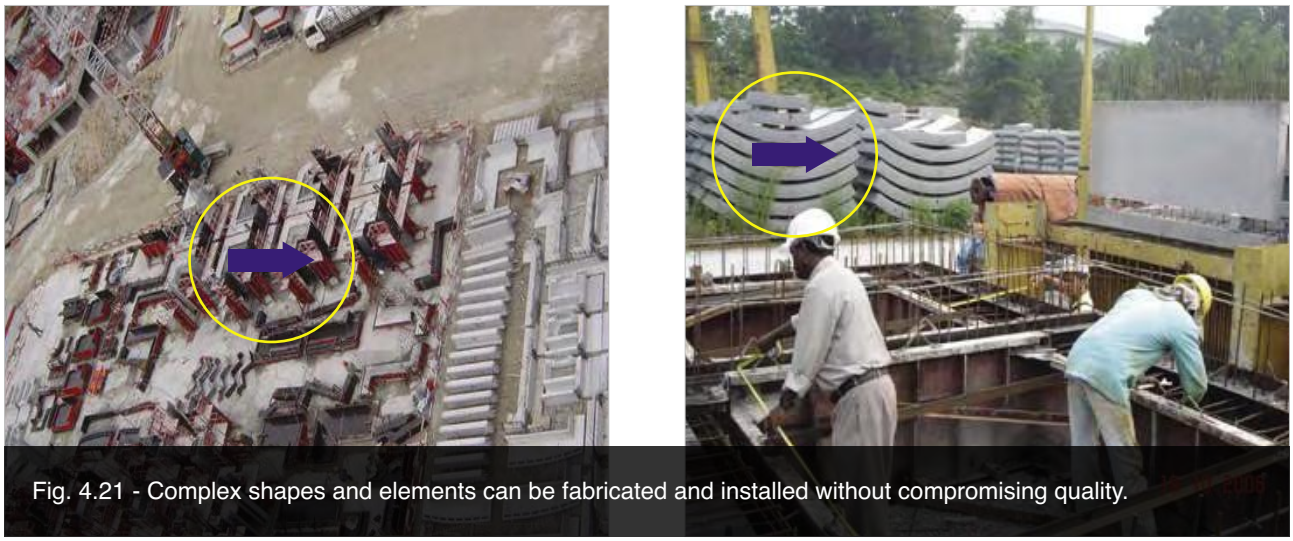


Fig. 4.21 - Complex shapes and elements can be fabricated and installed without compromising quality.

4.2.6 Speed and Productivity

Traditional concrete construction involves many trades such as formwork, rebar and concreting. These activities have to be carefully planned and co-ordinated in a non-conducive site environment which affects the speed of construction and quality of output. In contrast, precasting is carried out in controlled factory environment leading to ease of production and better quality output.

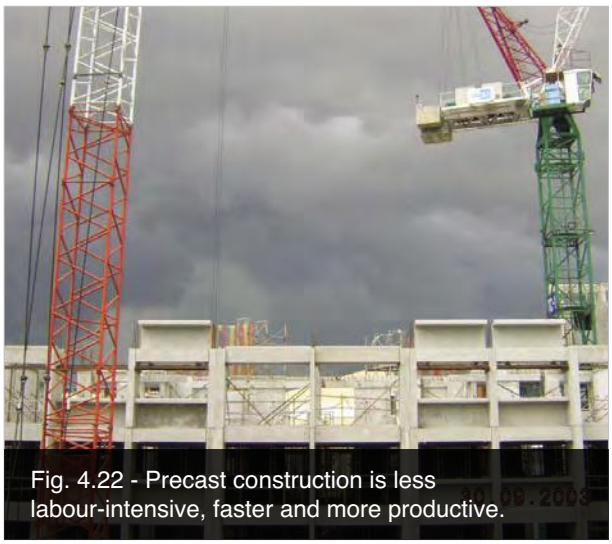


Fig. 4.22 - Precast construction is less labour-intensive, faster and more productive.

4.2.7 Better quality external wall

Alignment, verticality and surface finish of external elements are critical areas in building facade. Factory made precast wall panels require minimal surface preparation before final finish. Scaffolding is generally not required for the finishing works. This makes the construction site tidier and the works can be carried out faster, apart from savings in scaffolding cost. Typical quality problems in traditional plastered external walls such as hollowness, plaster waviness and cracks can be avoided when precast external facade system is used.

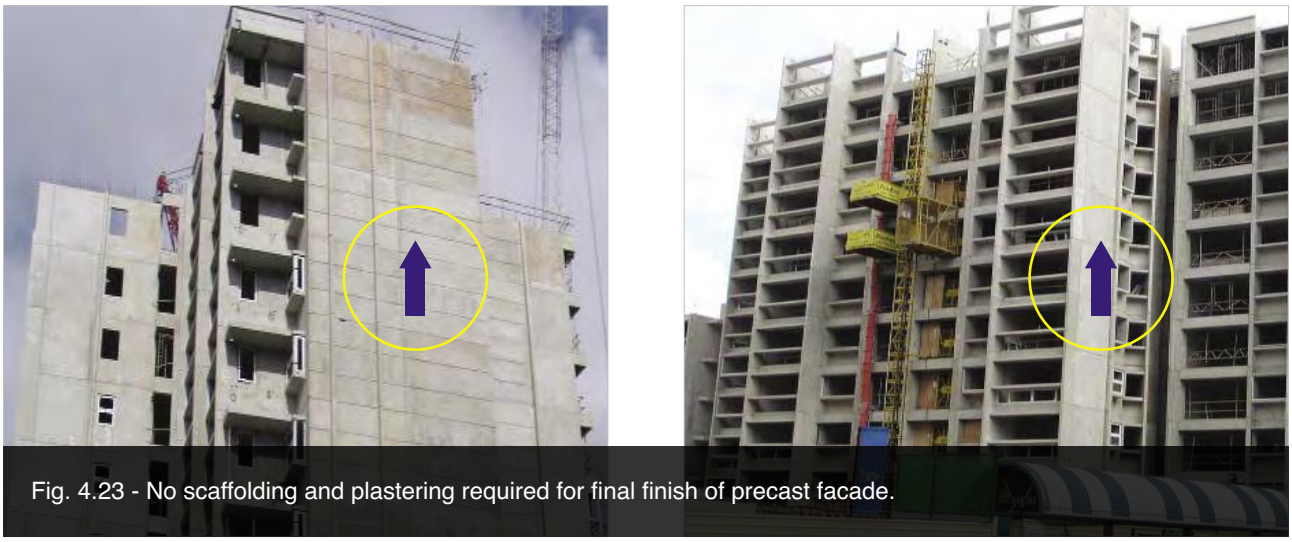


Fig. 4.23 - No scaffolding and plastering required for final finish of precast facade.

Fig. 4.24 - Traditional formwork construction: Untidy scaffolding and uncertain build quality outcome.

4.2.8 Challenges in precast installation

To reap the full benefits of using pre-cast elements, it is important to ensure that pre-cast elements are installed properly. Results from CONQUAS assessments show that despite the expected better finish surfaces, cracks and damages are frequent non-compliances for precast elements. This is often the result of damage to the components during transportation, lifting and installation.

Fig. 4.25 - Cracks and damages: Result of damage during transportation, lifting and installation.

Attention and planning are needed at the design and execution stage to prevent such damages. Provision should be made for lifting and handling devices within the pre-cast elements. The capacity of lifting equipment, gears, rigging arrangement, weight of precast elements, concrete strength and expertise of the installers are to be considered during transportation, lifting and installation. This will ensure the benefits of using pre-cast elements are not negated during final installation.

4.2.9 Optimizing design and use of recycled concrete aggregates (RCA) in precast elements

The use of precast concrete elements should incorporate sustainable development practices. This is in line with trends to optimize the use of natural resources and products and materials that are environmentally friendly. Recycled concrete aggregates (RCA) can be used to replace natural aggregates in non-structural components e.g. non-structural precast internal partition walls. This will reduce the depletion of natural resources by turning wastes into resources through reuse and recycling.

Where it is not possible to use such alternative materials e.g. in structural precast concrete components, the design should be optimized to achieve the most efficient sizes and reduced concrete usage.

5.0

QUALITY FEATURES IN ARCHITECTURAL ELEMENTS

5.1 PREFABRICATED BATHROOMS

5.2 DRYWALL PARTITIONS

5.0 QUALITY FEATURES IN ARCHITECTURAL ELEMENTS
5.1 PREFABRICATED BATHROOMS

Prefabrication technology is not new to the construction industry and has been in use for many years. Prefabrication permits components to be assembled in the factory under strict quality control before its installation on site. A prefabricated bathroom that integrates many trades can be employed to achieve consistent and high quality workmanship in a building.

This section features prefabricated bathroom systems currently used in private residential projects in Singapore, their advantages and contributions to high build quality.

5.1.1 Prefabricated metal panel wall system

A typical prefabricated bathroom comprises a 100mm thick concrete base slab, four surrounding walls of galvanized metal plates internally, dry wall partition externally and rock-wool insulation infill. It may weigh about 3 tonnes and the full bathroom assembly, including sanitary fittings and finishes are produced at a factory in a controlled environment.

Fig. 5.1- Assembling bathroom in a factory environment: Allows proper coordination and achieves better quality.

• *Key assembly activities in factory*

Fig. 5.2a - Base concrete slab casting.

Fig. 5.2b - Arrange wall tiles for fixing with glue adhesive.

Fig. 5.2c - Metal panels mount on wall tiles.

Fig. 5.2d - Fix metal panels to base slab.

Fig.5.2e - Carry out M&E installation & testing.

Fig. 5.2f - Pack and deliver to site.

5.0 QUALITY FEATURES IN ARCHITECTURAL ELEMENTS
5.1 PREFABRICATED BATHROOMS

• Quality and other features in prefabricated bathrooms

- Consistent and quality workmanship

In the conventional system of constructing a toilet, many trades include concreting, brickwork, waterproofing, screeding, tiling, plumbing, electrical works, components, etc have to be properly sequenced and coordinated on site to avoid delays. There is greater difficulty in achieving build quality as the work of some trades may be damaged by others in the process. The multiplicity of trades also creates uncertainties on the project duration. With prefabrication, the quality of the finished product can be better assured with greater consistency.

Fig. 5.3 - Better quality and consistency in prefabricated components.

- Tile joint consistency

Inconsistency in tile jointing is one of the most frequent non-compliances encountered in wet method construction particularly for wall tiles. This is substantially reduced when dry installation method like prefabricated bathrooms is employed. In this method, the tiles are placed horizontally on a leveled platform and spacers are used to ensure consistent joint widths. Epoxy glue is then applied on both the tiles and metal panels, and the panels are then mounted on the tiles. The wall tiles exhibit consistent joint widths after drying.

Fig. 5.4a -Tiles are placed on a leveled platform with spacers and glue adhesive.

Fig. 5.4b - Panels are mounted on the tiles.

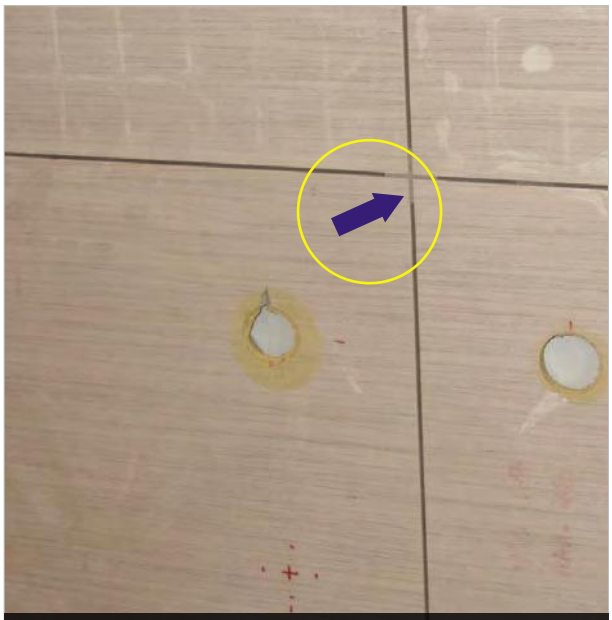


Fig. 5.4c - Consistent tile joints achieved in dry installation.

- Less lippage or unevenness

In a typical wet method construction, lippage or unevenness in wall tiling is frequently the result of unskilled workmanship. More skill is required when the tiles are placed vertically on walls using adhesives. This dependency on skilled labour is reduced in prefabricated construction where the tiling work is set out horizontally on a leveled surface and fixed to the metal plate using a thin layer of glue adhesive. The chance of lippage or unevenness is very much reduced if good quality tiles without manufacturing defects are used.

Fig. 5.5a - Tiles are fixed to metal panels with a thin layer of glue adhesive.

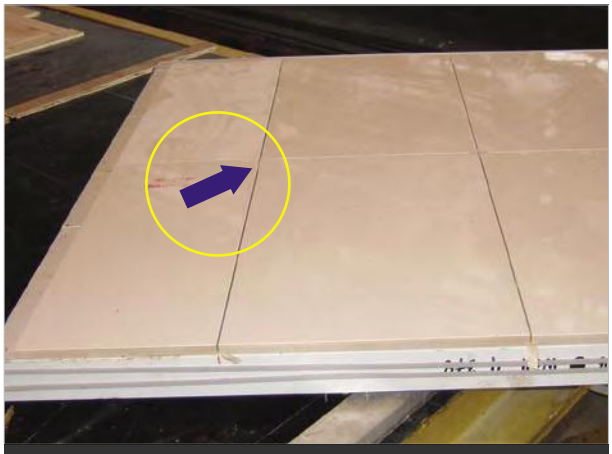


Fig. 5.5b - Flat and even tile surface finish.

- No de-bonding or hollowness

Hollowness or de-bonding of tiles arises primarily due to improper workmanship or incompatibility between the substrate/tile and adhesive. In some cases, inadequate tensile strength of the adhesive may cause de-bonding. In prefabricated bathrooms, glue adhesive is used instead of normal adhesives. The bonding strength of such adhesive is much greater than cement-based adhesives and this reduces tile hollowness or de-bonding.

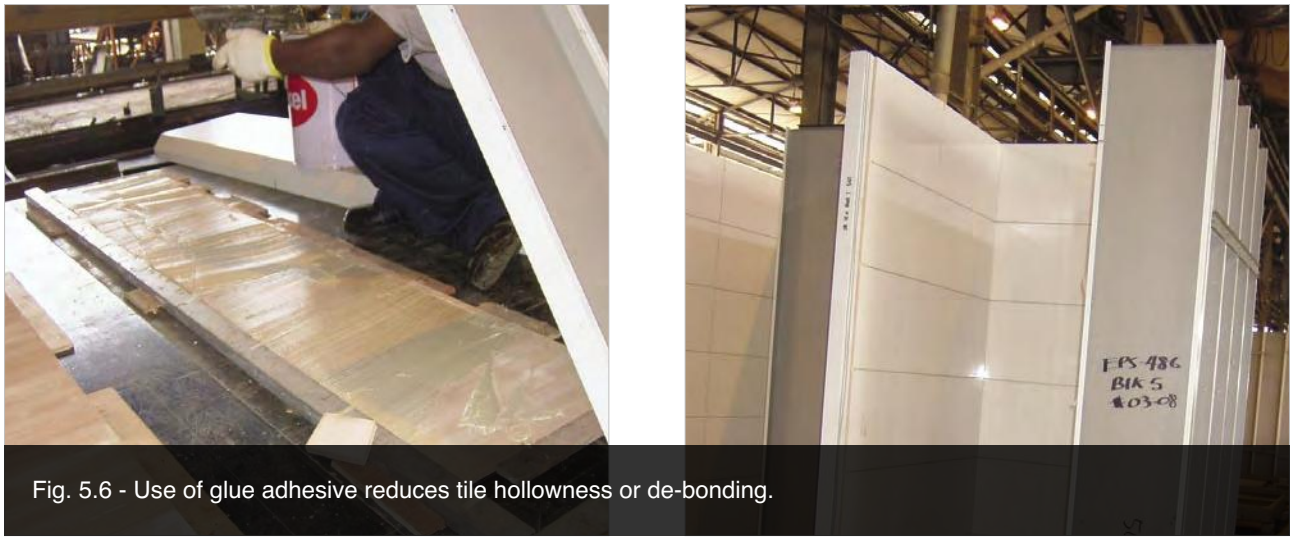


Fig. 5.6 - Use of glue adhesive reduces tile hollowness or de-bonding.

- Ease of forming gradient in base slab casting

Most wet areas including bathrooms need to be built with a gradient towards the floor trap to discharge waste and prevent water puddling. Typically, the gradient is formed during floor screeding using cement-sand mortar. In some situations e.g. protrusion of concealed pipes on the floor, it may be difficult to form the required gradient using the base screed. As a result, the correct gradient is formed using tile adhesives when laying the tiles. However, this is not a good practice to form the required gradient.

In prefabricated bathrooms, the tiles are laid directly on the concrete slab without screed. The correct gradient is formed by the mould and the concrete casting is carried out while the mould is in reverse position. After curing and removal of the mould, the base slab is turned to its original position. Therefore no screeding is required and consistent adhesive thickness can be maintained when laying tiles. The final gradient is also precise according to design.

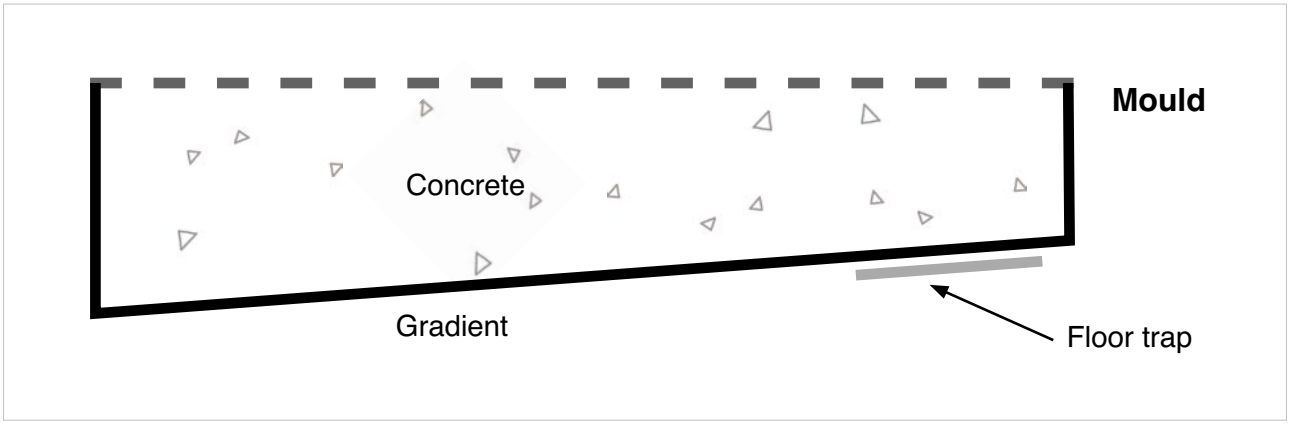


Fig.5.7 - Floor tiles are laid without screeding. The required gradient is formed while casting base slab.

- Non-critical path erection

Prefabricated bathrooms can be hoisted by a tower crane and installed after completion of structural slab castings. It can be considered as a non-critical path process since its fabrication and installation does not affect other concurrent activities on-site as in conventional wet trades method. The bathroom is simply supported on the structure and the whole installation can be executed rapidly in a tidy manner.

Fig. 5.8 - Bathroom is lifted into place by a tower crane after completion of structural work.

Fig. 5.9a - A cantilever platform is used to rest and direct bathroom into place.

Fig. 5.9b - Simply supported connections secure bathroom in place.

5.1.2 Prefabricated bathroom with precast concrete wall

Prefabricated bathrooms are produced using thin precast walls with a solid base as a frame. This standardization allows close quality checks before installation. Careful planning, sequencing and inspection of trade works are carried out in the factory to achieve the required quality. The following images show the sequence of important activities in the process.

Fig. 5.10a - A standard mould casts precast base and walls together for better water-tightness.

Fig. 5.10b - Precast frames are cured before starting other trades.

Fig. 5.10c - Apply waterproof membrane and water-ponding test.

Fig. 5.10d - Checkered internal surfaces for installing tiles without basecoat.

Fig.5.10e - Final ponding test for completed bathrooms.

Fig. 5.10f - Install sanitary fittings and accessories.

Fig. 5.10g - Delivery and installation by tower crane.

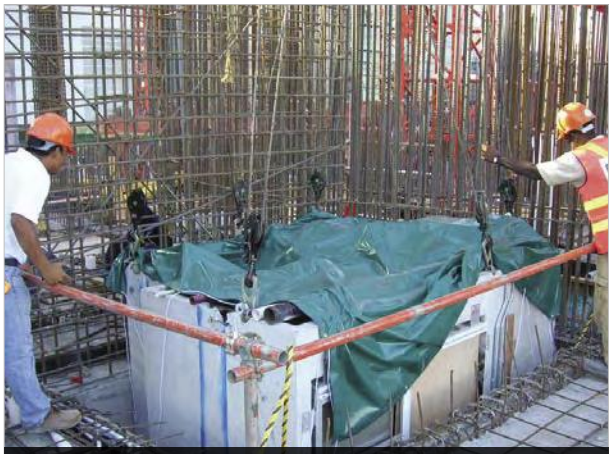


Fig. 5.10h - Less intensive manpower needed during installation.

Fig. 5.10i - Tidy and dry construction process.

Fig. 5.10j - Quality internal finish.

The advantages of this system include:

- Mould can be used for repeated production.
- Time spent in unfavourable weather conditions at construction site is minimized.
- Reduce on-site assembly.
- Increase installation efficiency and speed of construction.
- Improve buildability and productivity.
- Increase social and environmental benefits.
  (safe and healthier working environment through less site work).
- Service pipes are concealed during casting of structure for better reliability, performance and aesthetics.

5.1.3 Prefabricated bathroom and integration of bay window

It is not uncommon for bay windows to be integrated with prefabricated bathrooms. This further reduces the number of trade activities on site that includes bay window installation. The weight of such integrated units, about 6 to 8 tonnes each, are heavier but the production, fitting, testing and finishing works can all be carried out in a controlled factory environment leading to better quality product and workmanship.

The images below show the key sequences in fabrication and installation of the integrated system:

Fig. 5.11a - Precast base and bay window unit.

Fig. 5.11b - Apply waterproofing on metal wall panels.

Fig. 5.11c - Erect panels on base slab.

Fig. 5.11d - Apply waterproofing on floor and wall joint.

Fig. 5.11e - Install tiles on panels with special adhesives.

Fig. 5.11f - Install window frames.

Fig. 5.11g - Long-bath installation.

Fig. 5.11h - Floor tiles installation.

Fig. 5.11i - False ceiling erection.

Fig. 5.11j - Install window inner frames.

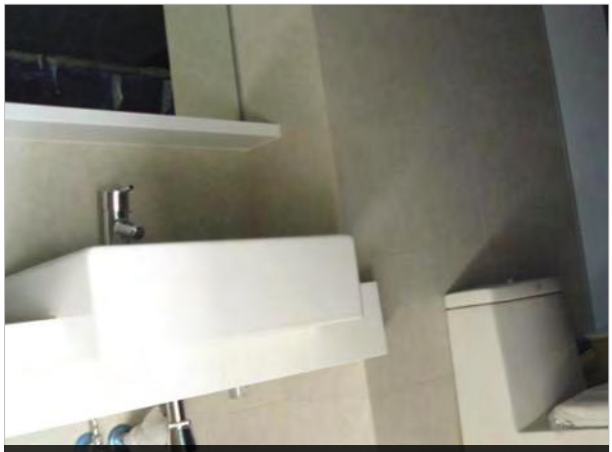


Fig. 5.11k - Install sanitary fittings.

Fig. 5.11l - Water-ponding test.

Fig. 5.11m- Delivery to site.

Fig. 5.11n- Install by tower crane.

5.1.4 Key considerations in prefabricated systems

To maximize the benefits of using prefabricated bathrooms, the project team should consider integrating such systems during the early stages of the project (concept and scheme design). Once the scheme design has been finalised, there is limited scope and value in exploring prefabrication options. In fact, it may cause disruptions to the original design and this can delay the project.

Large prefabricated sections require heavy-duty cranes capable of handling and precise maneovreing to place it in position. A proper sequence of erection and inspection should be established to ensure quality in fabrication and installation. When adopting metal panel wall systems, attention has to be paid to the strength, corrosion-resistance and treatment of joints on the panels to avoid future malfunctions.. Furthermore, proper guidelines should be given to end-users when they wish to retrofit tiles and other fittings in the bathroom in future.

Recent trends in Singapore show wider adoption of dry construction methods like internal drywall partitions in substitution for wet trades like brickwork and plastering. The following section describes the quality features of drywall partitions, its use, advantages and contributions to improved workmanship quality.

Fig. 5.12 - Internal drywall partitions: Increasingly used in residential buildings.

5.2.1 Features of drywall partitions

• *Sustainable building material*

Drywall partitions are produced mainly from recycled materials available from many sources and uses low energy in the production process. It is therefore environmentally friendly and contributes to sustainable construction. Some brands of drywall partitions are certified as green building material under Singapore Green Labelling Scheme (SGLS).
(Ref: http://www.sec.org.sg)

Fig. 5.13 - Some brands of drywalls are certified as green building material.

• *Light weight and strong*

Drywalls are light weight leading to significant reduction in dead loads. This allows designers to design for lighter structures and foundations, leading to savings in structural cost. The wall system is able to resist high impact forces and it can support loads such as TV, cabinets, shelves, etc. attached to it.

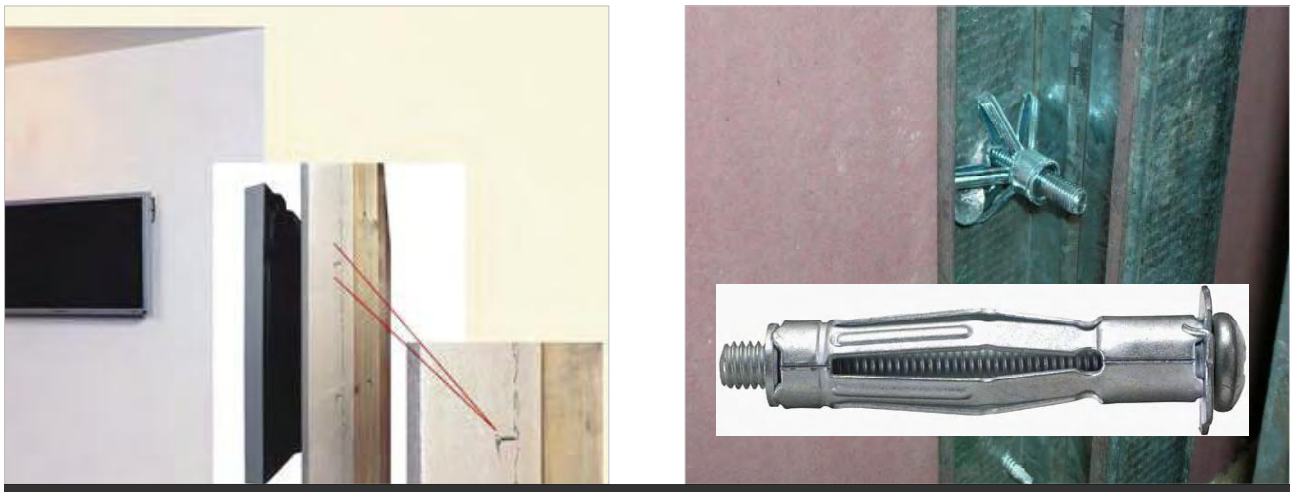


Fig. 5.14 - Proper anchorage system facilitates mounting of TV, shelves and cabinets on drywall partitions.

• *Enhance productivity*

Drywall systems are faster to erect in contrast to traditional construction methods such as brick and block work. The productivity rate is 15-20m^2 / manday compared to about 4-7m^2 / manday for brickwork. The partitioning works can be completed faster leading to improved construction duration.

Fig. 5.15 - Increased productivity & reduced construction time.

• *Ease of installation and quality outcome*

The method of installation is fast and efficient. Alignment and verticality can be controlled easily at the outset during setting out and stud erection. The stud system facilitates alignment of the boards in the same plane. A flat and smooth surface is achieved by applying only a thin coat of plaster putty and sanding it before painting.

Fig. 5.16 - Ease of installation.

Fig. 5.17 - Stages of drywall erection

• *Neat concealment of services*

Penetrating walls and concealment of services are inevitable in construction works. Generally, end-users prefer service pipes, cables and trunkings to be concealed otherwise it would affect the aesthetic appearance of the building.

In drywall partitions, the two layers board system can conceal many services without hacking and damage. Penetration through the boards can be achieved with neat cuts unlike conventional wet methods of construction where hacking (ref Fig. 5.20) and patching up are often messy and untidy and may lead to unwanted consequences like water seepage, hollowness, etc.

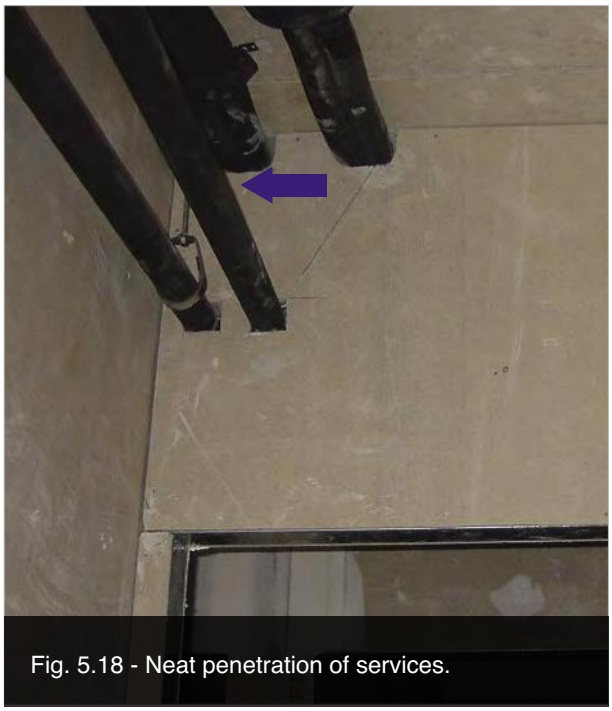


Fig. 5.18 - Neat penetration of services.

Fig. 5.19 - Installation of concealed services.

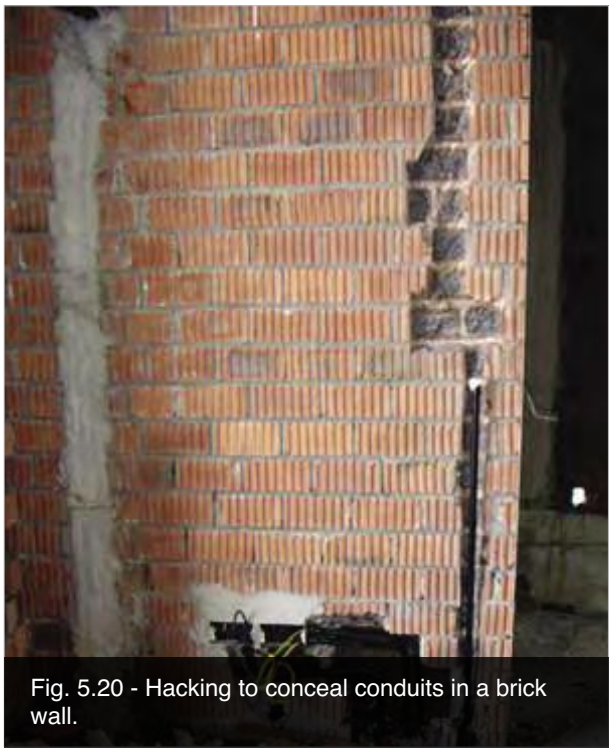


Fig. 5.20 - Hacking to conceal conduits in a brick wall.

• *Better acoustic performance*

Provision of insulation like rockwool between the boards enhances the soundproofing and acoustic performance of drywalls. The sound transmission class (STC) value of brick or concrete walls is typically about 40. Drywalls with rockwool insulation can achieve better STC values of 45-50.

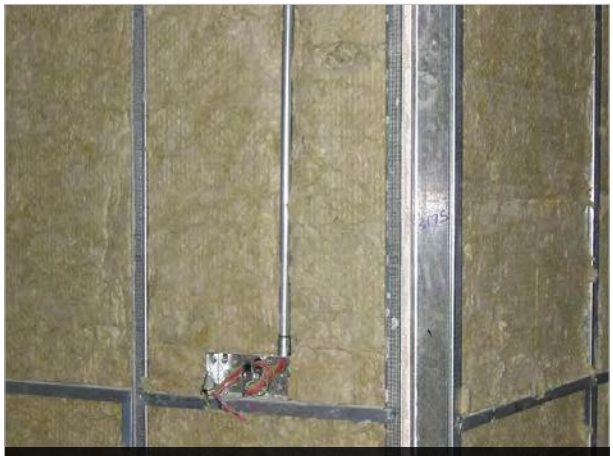


Fig. 5.21 - Rockwool insulation enhances acoustic performance.

5.2.2 Quality trends in internal finishes assessments

Internal wall finishes is one of the elements assessed under CONQUAS. The pie chart shows non-compliance data on internal wall finishes collated from private residential projects assessed under CONQUAS from 2005 to 2007. Among the 5 items assessed, the most frequent non-compliances are in finishing and joints. The frequency of such defects are generally higher in cement-based plastered walls.

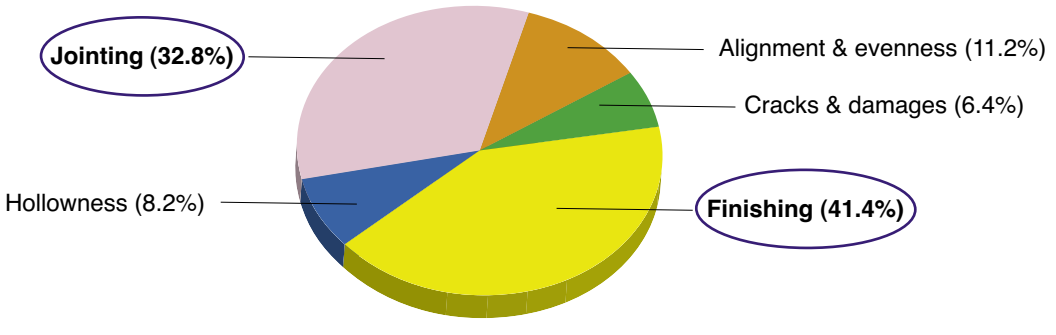


Fig.5.22 - % Defects distribution for walls of private buildings.

A separate study on projects (see Chapter 8) with high CONQUAS scores reveals that adopting drywall systems significantly reduced the non –compliances on internal walls. The quality of the finishing works that can be attained is better than conventional plastering works.

5.2.3 Quality features in drywall partitions

The following highlights the inherent advantages in drywall systems leading to better workmanship quality.

• Minimize defects on wall finishes

Rough surfaces and inconsistent paint finishes are the most frequent non-compliances in plastered walls. The smoothness, consistency and texture in paint work are very much dependent on the substrate surface. If the substrate is smooth and not wavy, it will be easier to achieve good paint work either by roller or spray method. Drywall systems present an even board surface which can be prepared easily with a thin layer of putty and sanding it before painting.

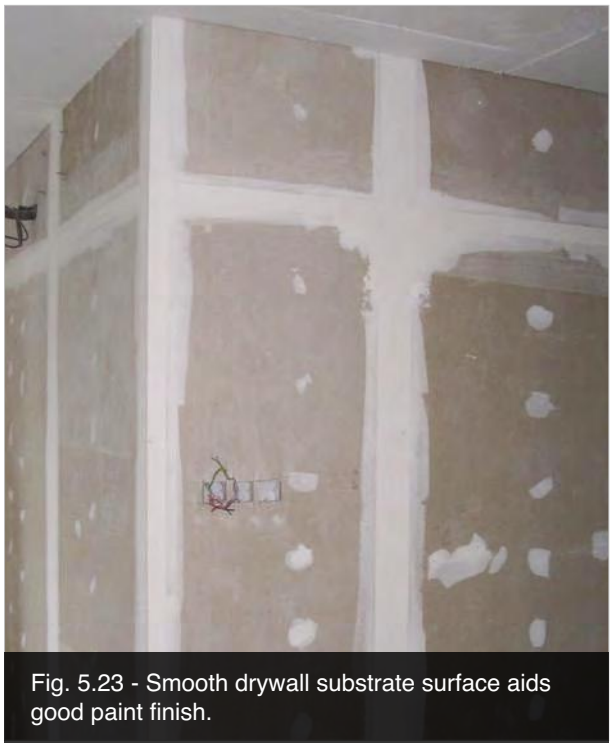


Fig. 5.23 - Smooth drywall substrate surface aids good paint finish.

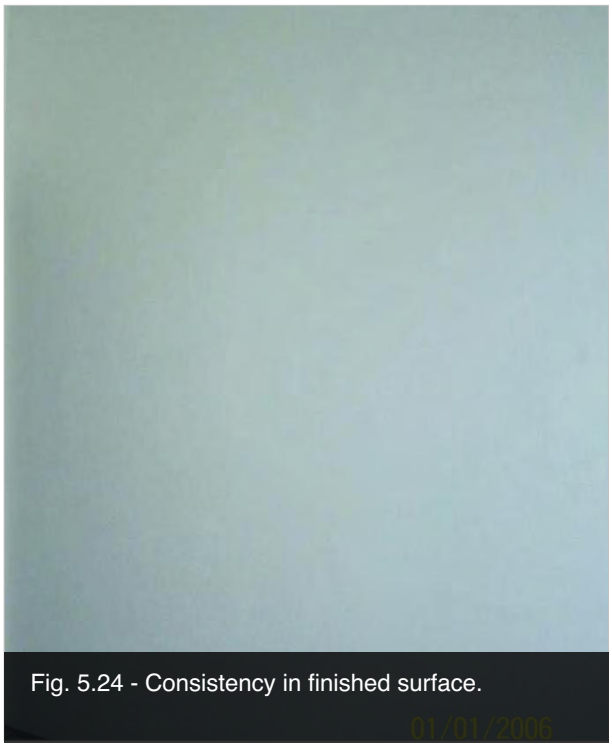


Fig. 5.24 - Consistency in finished surface.

• *No plaster hollowness*

In conventional brickwork, thick coats of plastering may be required to compensate for bricks not properly laid and to get a balanced smooth finish. This often results in hollowness and de-bonding when the plaster work is too thick or not carried out properly. In drywalls, only a thin layer of skim coat is sufficient to get a smooth surface. There is no risk of hollowness or de-bonding.

Fig. 5.25 - Thick plaster coat is main cause of hollowness in conventional masonry work.

Fig. 5.26 - No hollowness risk in drywall skim coat.

• *Less alignment and evenness defects*

During erection of studs for drywalls, alignment and verticality can be easily controlled. Once the studs are properly installed, the boards can be fixed on them evenly. There is no need for thick plastering to get an even surface.

Fig. 5.27 - Alignment and verticality are controlled when erecting studs.

Fig. 5.28 - Less occurrence of mis-alignment and unevenness.

• *Less wall joint defects*

In wet plastering works, more manual skill is required to make a joint between two straight walls notwithstanding the use of additional aids like angle and inner beads to achieve a neat joint. This is due to difficulties in trying to combine two or three layers of plaster together. In drywall systems, only a thin coat of joint compound is required as straightness and alignment are controlled during stud erection leading to neat and straight joints at wall intersections.

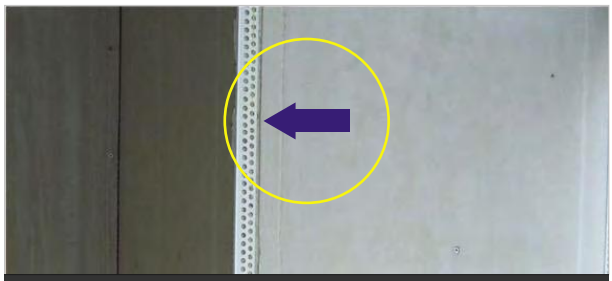


Fig. 5.29 - A thin corner-bead helps make corner straight.

Fig. 5.30 - A neat and straight internal wall joint.

5.2.4 Examples of good practices in drywall construction

To derive maximum benefits from using drywall systems to achieve workmanship quality, it is important to pay attention to certain details.

• *Details to prevent cracks at joints*

Hairline cracks may appear over time at drywall joints. This is particularly so after the air-conditioning is in use. Such cracks can be prevented if proper installation and joint treatment are observed.

According to a manufacturer's recommendation, in addition to following a proper method of stud and board erection, a joint tape should be provided to bridge the joints of the drywall before the skim coat is applied. This will control the movement between the boards and prevents cracks from forming. It is also recommended to avoid horizontal joints on the boards. An appropriate paint system (silicone based) may prevent hairline cracks from appearing in certain cases.

Fig. 5.31 - Joint tape and joint compound to reduce risk of cracks.

Cracks can also appear at the joint between two different materials due to differential expansion and contraction of the materials and temperature changes.

To prevent this, some projects use a drywall board to cover the RC surface (see Fig. 5.32).

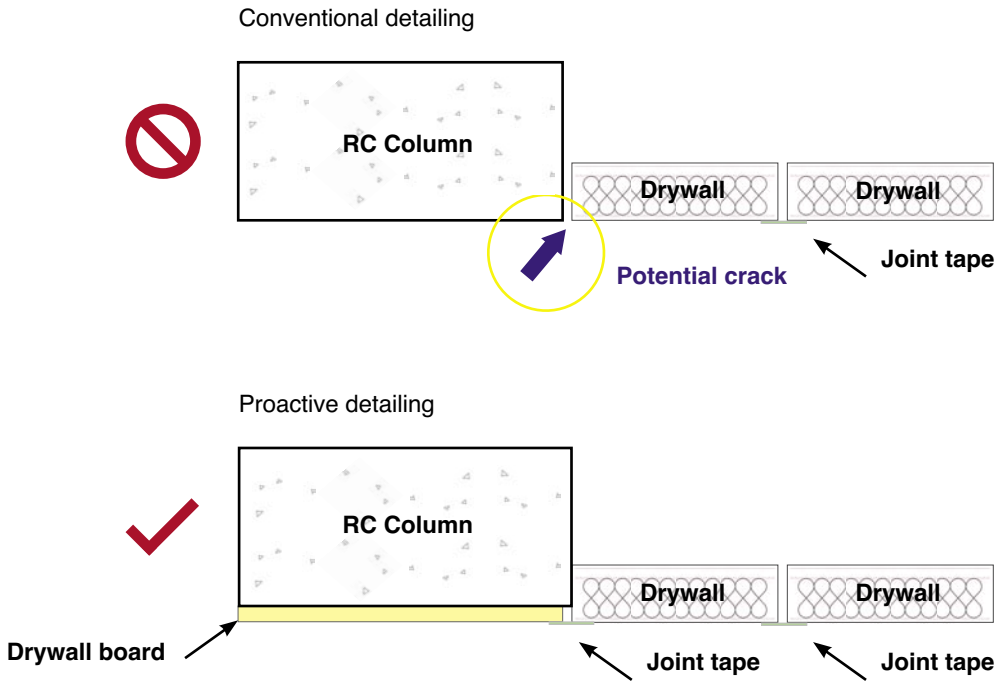


Fig. 5.32 - Drywall board covers RC column to prevent cracks at joint.

This detailing will minimize the appearance of cracks at joints. In addition, the whole premises will have a uniform finish and it is also easier to carry out the subsequent works like application of joint compound and painting. However, this detailing may reduce the space in the room (by the board's thickness of about 12 to 19mm).

• *Additional supports for door frames and large openings*

To prevent distortions and sagging of openings, the studs need to be stronger to cope with the weight of the door and forces caused by slamming. Typically this would involve boxing the studs or sleeving them with a channel, as well as including timber inserts. The standard details for forming door jambs are illustrated in Fig.5.33, although other suitable timber framing assemblies may be required to adequately support heavier doors. For large openings, a stronger lintel (Fig.5.34) may be required. It is also important to ensure openings are accurately formed to prevent uneven gaps or creaks caused by movement between ill fitting members.

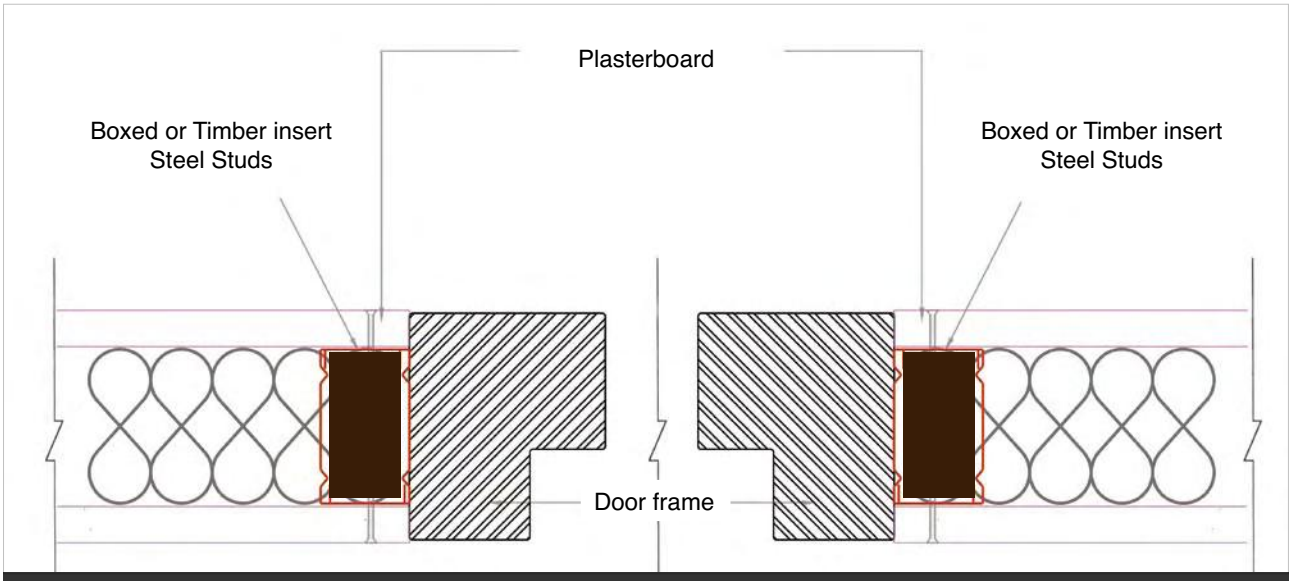


Fig. 5.33 - Additional timber inserts strengthen door frames.

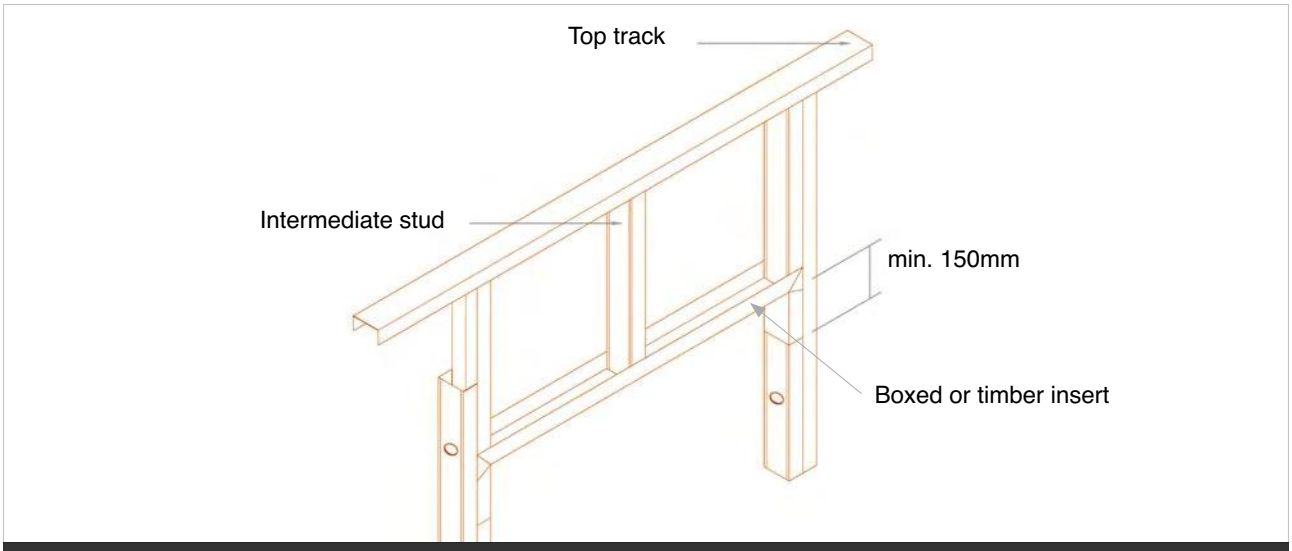


Fig. 5.34 - Timber insert at top acts as lintel for door frame.

5.2.5 New trends in use of drywalls

• Drywall cladding over RC wall

In some projects, the whole inner RC surface areas are clad with drywalls to have a uniform finish throughout the unit. In practice, RC walls require a skim-coat finish while drywalls require a joint compound finish. Adoption of this method is to avoid using two different finishing materials for different surfaces in the same unit. This system will reduce the internal area slightly and increase the cost. However the surface appearance and paint finishes will be consistent throughout the unit.

Fig. 5.35 - Drywall cladding over inner perimeter of RC walls.

Fig. 5.36 - Uniform surface finish throughout the premises.

• Board partitions in wet areas

Some boards are now fabricated with moisture resistant properties and are suited for use in wet areas. The boards are also coated for bonding with tile adhesives and waterproofing membranes and are resistant to mould growth. It has a homogeneous structure that impedes de-lamination under moist conditions. Although widely compatible adhesives are available in the market, it is a good practice to carry out compatibility test prior to use. In addition, installing studs on concrete kerb in wet areas is also a good practice to prevent consequences from stagnant water.

Fig. 5.37 - Stud erection on a concrete kerb in wet areas.

Fig. 5.38 - Drywall partition with waterproofing membrane.

The concealed services in wet areas like water and sanitary pipes can be installed without untidy hacking and patch-up. This is a faster and less cluttered process. However, the use of board systems for wet areas is only a recent trend and its performance should be further monitored and evaluated based on end-user feedback.

Fig. 5.39 - Installation of wall finish on board partition by using adhesive.

Fig. 5.40 - A completed toilet with wall finish on board partitions.

5.2.6 Other considerations in drywall partitions

To achieve maximum benefit in drywall construction, the manufacturer's guidelines should be strictly followed during the installation process. Some detailing may need to be revised to suit the project and this should be clarified with the supplier or specialist professionals. It is also advisable to provide an instruction manual to the end-user illustrating, among other things, how to anchor and install TV, cabinets or shelves on the board partitions.

6.0

DESIGN AND DETAILING FOR QUALITY IN ARCHITECTURAL COMPONENTS

6.1 TIMBER DOORS

6.2 CABINETS AND OTHER COMPONENTS

6.0 DESIGN AND DETAILING FOR QUALITY IN ARCHITECTURAL COMPONENTS

6.1 TIMBER DOORS

Door is an essential element in buildings. Some door designs and detailing inherently lend itself to good quality outcome. This section illustrates some such examples which can be considered to improve workmanship quality.

6.1.1 Pocket door system

Pocket door (also called slide and hide) system is now widely used in residential projects. The sliding door panel is hidden within the hollow section between walls and operated on a track and roller system fixed at the top of the door panel (Fig. 6.1). This system enhances spaciousness in the unit, as the sliding door is hidden from view when it is open.

However, in most cases it is not feasible to provide tracks at the bottom of the door panel as this is fixed on the floor and may cause inconvenience to users e.g. tripping or creating a barrier. Dirt and dust can also accumulate inside the track and this needs to be cleaned periodically. Most designs therefore specify the track to be installed at the top only.

In such designs, the door panels are typically about 2.1m high and the whole panel hangs from the top track. When the doors are in closed position and butt against each other, any misalignment can be noticed easily due to uneven butt gap and different levels of the adjoining panels (Fig 6.2).

Fig. 6.1 - A pocket door system hung on top track enhances spaciousness in a unit.

Fig. 6.2 - When door is closed and butt against each other, any misalignment is easily noticed.

• *Tongue and groove profile to improve alignment*

The inherent difficulty in aligning top-hung pocket door panel system can be overcome or minimized by introducing a tongue and grove profile on the butt edges of adjoining door panels (Fig. 6.3 & 6.4). It provides a better fit of the butt ends and less possibility of gaps or misalignment when the door is in closed position.

Fig. 6.3 - Tongue and grove profile at butt edges in a pocket door system.

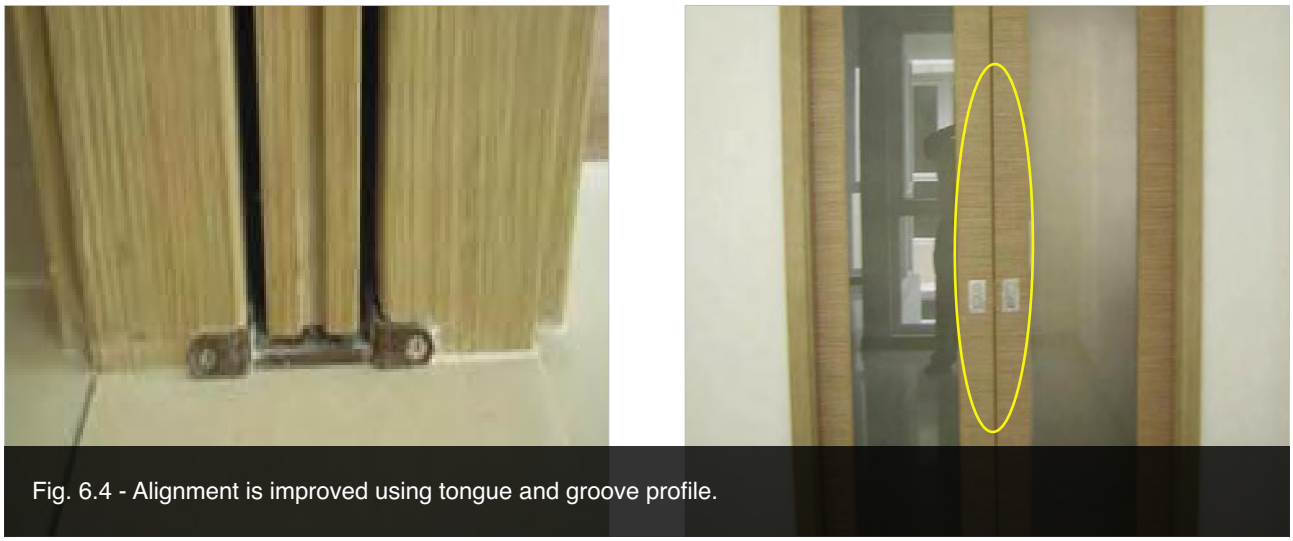


Fig. 6.4 - Alignment is improved using tongue and groove profile.

6.1.2 Sub-frame door system

In conventional construction, door main frames are fastened directly to masonry works. Major architectural works like flooring and skirting are carried out after the frame installation. These subsequent activities can cause damage to the door frames. In addition, where the flooring adjoins the frame, it has to be cut to follow the frame's profile. This usually requires skill and more time to complete. If the flooring comprises high density material e.g. granite flooring, etc. this task will be more difficult to execute.

Fig. 6.5 - Traditional main frame system: Flooring material laid after installation of door frame needs to be cut to suit door frame profile.

To get round this challenge, a sub-frame system which is widely used in private residential projects but less so in public housing and commercial buildings, can be employed. A door sub-frame is first built into the wall construction and the main frame is installed at a later stage i.e. after completion of the major wet trades. This reduces the risk of damage by other trades during construction. The other advantages of such a system are:

- The main frames are less likely to shrink and warp since it is not directly in contact with any masonry structures.
- The floor finish below the frame can be installed more easily. It need not be cut to suit the door frame's profile since the frame is installed after the floor finishing works.

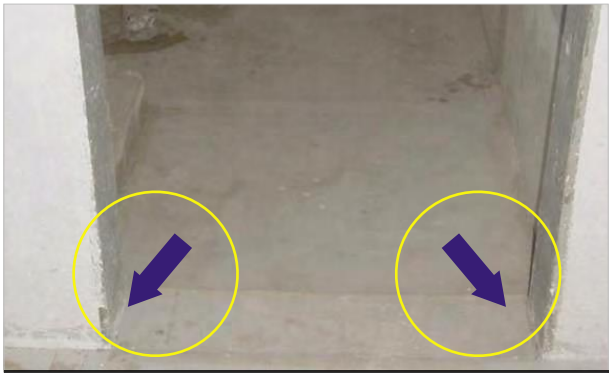


Fig. 6.6 - Door sub-frames installed before main frames: Adjoining floor installation need not be cut to door frame profile.

Fig. 6.7- Main frame installed after completion of floor finish. A neat joint is achieved below the door frame.

6.1.3 Rebate door with lift-off hinges

Rebate doors with lift-off hinges are gaining widespread use in private residential projects. The door panel has a rebate profile that aligns with the door frame (Fig. 6.8). Furthermore, a PVC gasket is provided in between the frame and panel to make the gap less noticeable and aid in smooth functioning of the door when closing.

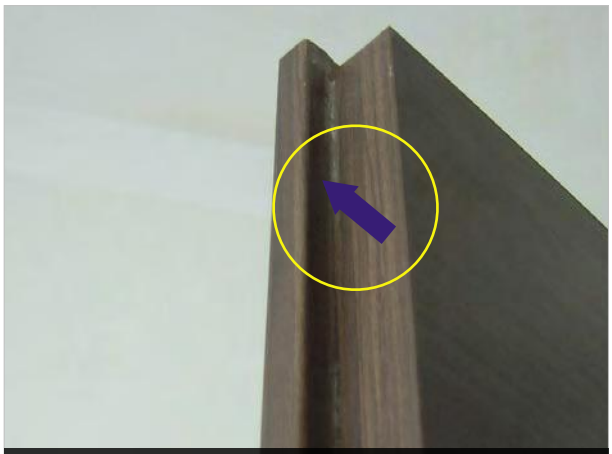


Fig. 6.8- A rebated door panel.

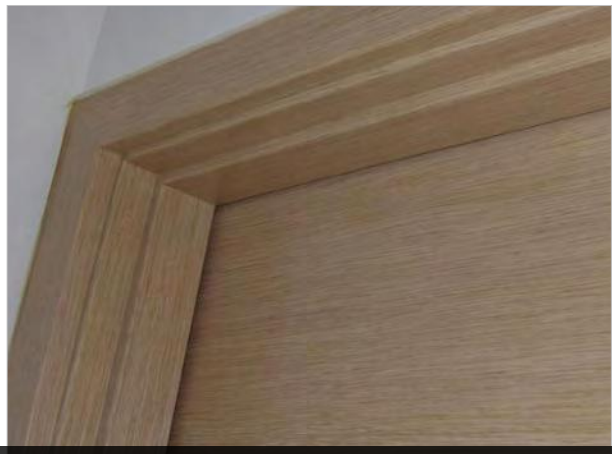


Fig. 6.9 - Better alignment consistency between door frame and panel.

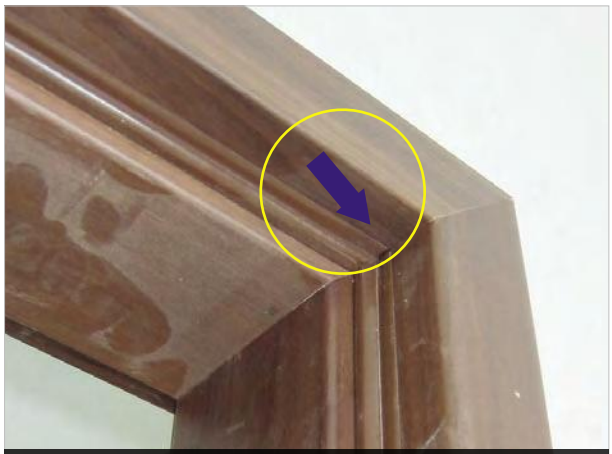


Fig. 6.10 - A PVC gasket makes door gap less noticeable and aids smooth operation.

The lift-up hinges system allows the door, together with the hinges, to be fabricated off site and slotted into place after the finishing trades have been completed. (Fig. 6.11)

Material damage on door is often a recurring non-compliance in CONQUAS assessments and frequent item of complaint by home owners during hand over. This is largely due to damage caused by other trades during construction, which can be minimized if the door panel is installed at the last stage. This lift-up hinges system allows installation of door panels at a very late stage of construction. Furthermore, the installation process is simple, quick and can be carried out without affecting other activities.

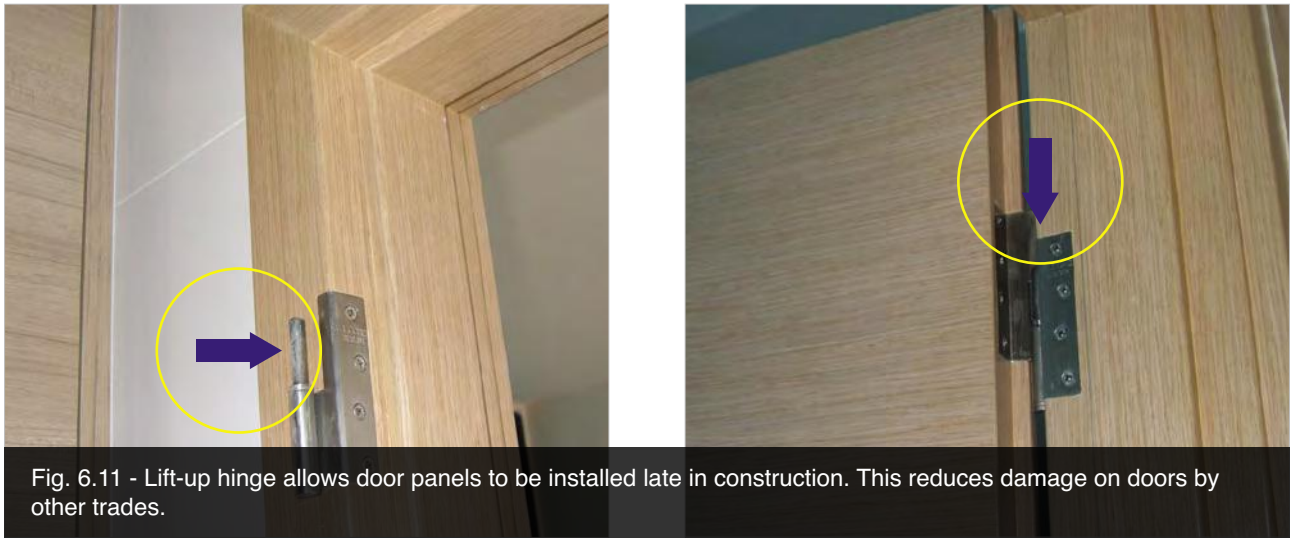


Fig. 6.11 - Lift-up hinge allows door panels to be installed late in construction. This reduces damage on doors by other trades.

6.1.4 Common quality issues in doors and its causes

The following data from CONQUAS assessments from 2005 -2007 highlight the key quality concerns in door construction viz. material and damages, joints and gaps, and alignment and evenness (Fig.6.12).

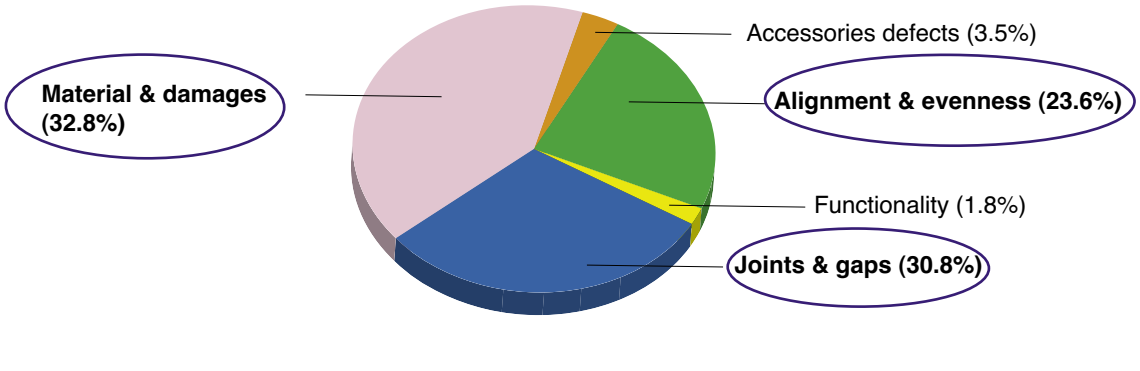


Fig.6.12 - % Defects distribution for doors for private residential buildings.

• *Material and damages*

Damages on doors are mostly caused by other trade activities. This is due to the interfacing of activities in traditional construction. To prevent this, door panels should be installed at later stage of construction and properly protected with suitable materials. A method like lift-up hinges door will help and expedite the installation process at later stage of construction without affecting other sequence of works.

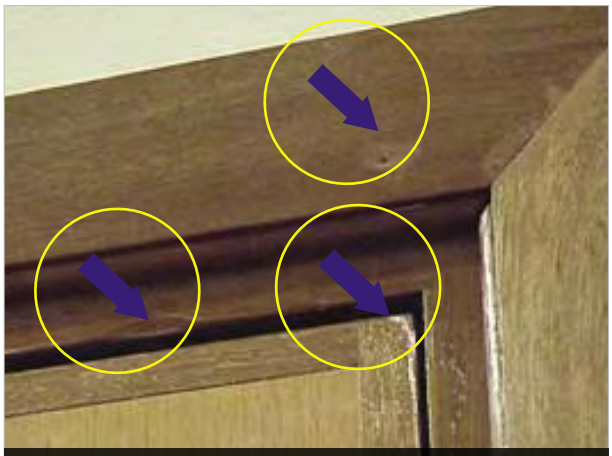


Fig. 6.13 - Dent, damage and nail-hole: Common damages on door panels.

• *Alignment*

Inconsistent alignment between a frame and a door panel is usually the result of warpage and twisting in the panel or frame. This could be due to inherent characteristics of the timber material used and its tendency to warp/twist is more likely when longer lengths of panel or frame are used. In such cases, the panel will not be aligned exactly with the frame, making it more noticeable. To minimize such defects, it is important to use materials that are properly treated and protected from moisture ingress and provision of better detail and profile on door panels.

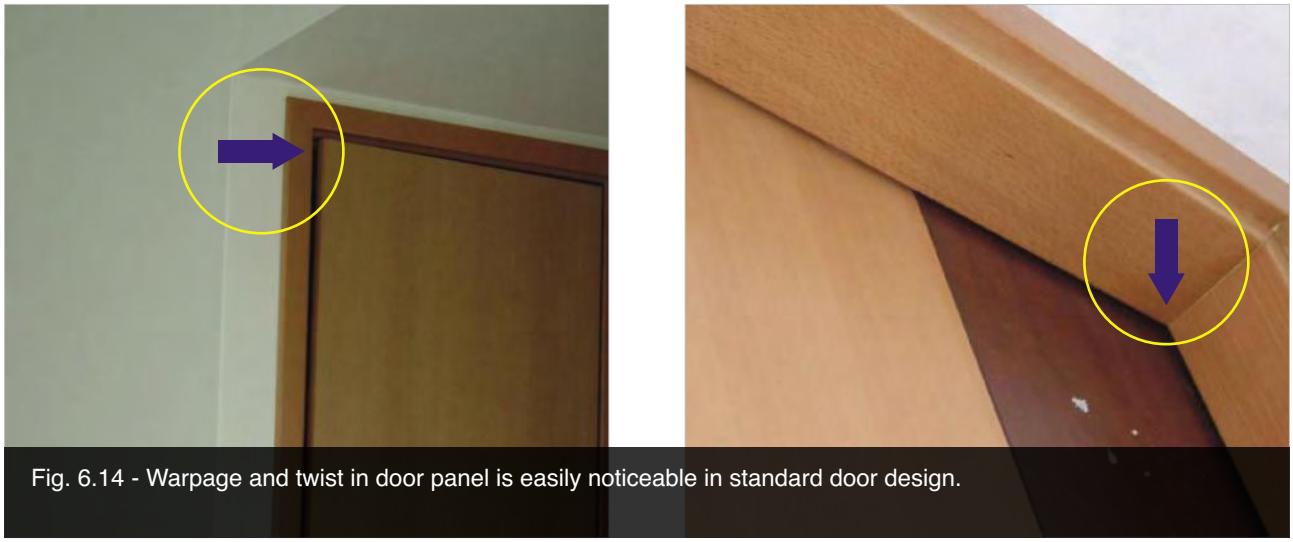


Fig. 6.14 - Warpage and twist in door panel is easily noticeable in standard door design.

• *Joints and gaps*

Uneven joint between door frame/wall, architrave/wall or rough joint between door frame and floor are usual quality defects. The process of joining door frame to wall often results in damaged edges and hairline cracks. Architrave is commonly used to cover any untidy joint between frame and wall and hide such cracks. After installing the architrave, the small gap between the wall and architrave can be properly sealed with material like silicone filling.

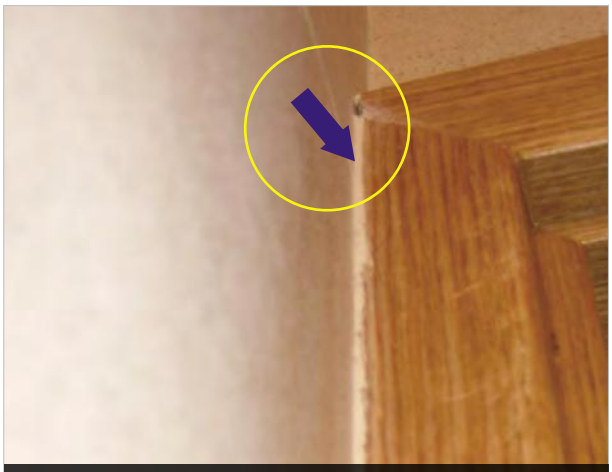


Fig. 6.15 - A poor joint between frame and wall.

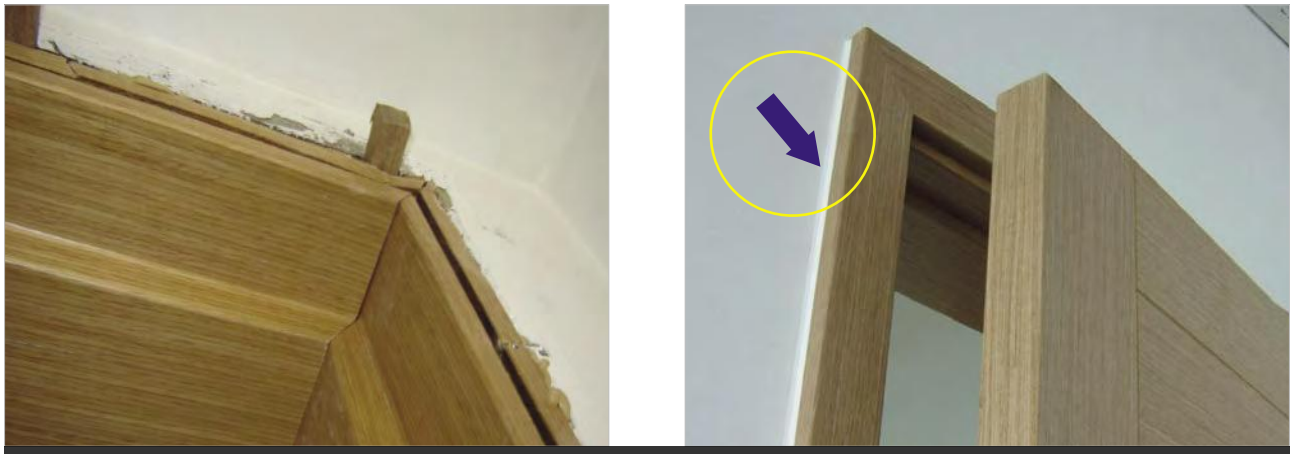


Fig. 6.16 - Architrave can be used to hide poor joints and cracks.

However, some detailing provides a groove around the door frame instead of architrave. This involves joining two different materials with differential expansion characteristics which pose problems especially in an air-conditioned environment. The possibility of hairline cracks occurring at the joint is high. It is also difficult to form the groove of uniform depth and width because of its smaller dimension. In addition, more attention and time need to be expended to paint the small groove. There is also challenge in achieving consistency in workmanship when this design is repeated in a large number of units.

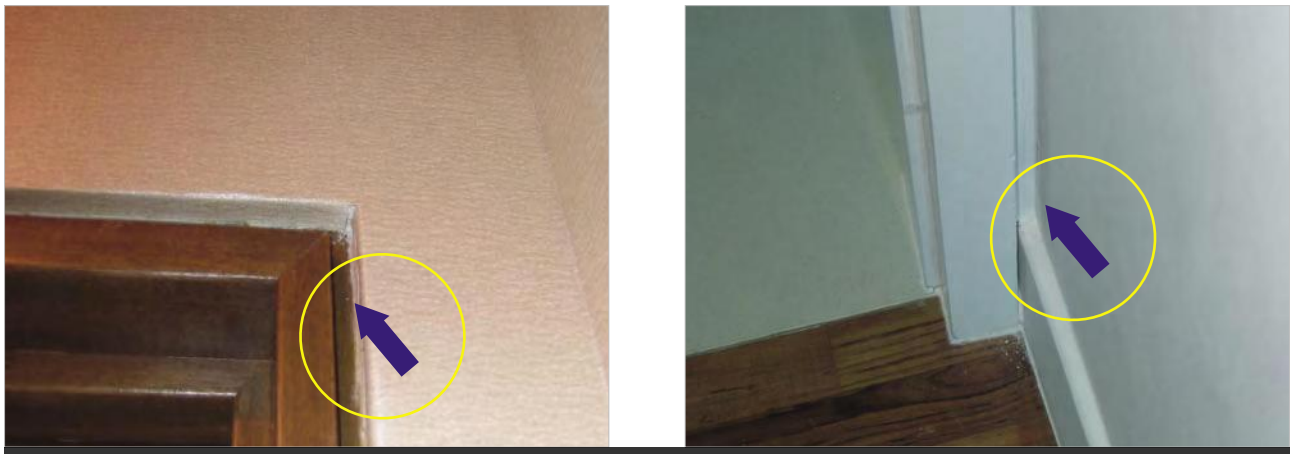


Fig. 6.17 - Groove around door frame instead of architrave: Needs more attention to form and treat.

The typical method of fixing hinges to doors is to recess the door frame and install one plate of the hinge by screws. The other plate is installed on the door panels by the same technique. This operation is highly dependent on the skill of the installer and is time consuming. The small gap between the frame and the hinge plate is to be filled with timber putty. Quite often, the fillings are untidy and the other challenge is to flush the plate to the same level of frame surface. This requires precise workmanship and it is not easy to maintain consistency in all frames throughout the project. The use of pre-assembled hinge systems like lift-up technique can minimize such joint problems in workmanship quality.

Fig. 6.18 - A traditional hinged swing door system installed by screws.

There is a wide range of timber door and ironmongery available in the market. This chapter highlighted and compared some commonly used designs and detailing in the industry. Assurance of quality and performance start at the factory where the door components are fabricated. However, when considering the door design and detailing, attention should be given to ease in erection, functional performance and maintainability. It is important to ensure the selected system meets the specified performance and functional requirements, especically the choice of ironmongery like hinges and other securing devices.

6.0 DESIGN AND DETAILING FOR QUALITY IN ARCHITECTURAL COMPONENTS

6.2 CABINETS AND OTHER COMPONENTS

The typical components in a residential project include wardrobe, kitchen and vanity cabinets, shoe rack, wash basin, shower screen and water closet (W.C.). This section highlights and compares the advantages in using preassembled (modular) system components over components that are cut and assembled on site. It also highlights how the selection of materials, accessories and its installation impacts the quality of the component.

There are many types of finishes available for use in cabinets. The common finishes include:

- Veneer
- Melamine
- Laminate
- Polykem
- Vinyl

These finishing materials can be installed on-site by manual labour or integrated into the component by machines in the factory. The following highlights the challenges in ensuring quality of the finished component when installation is carried on-site.

6.2.1 Challenges in on-site cutting, lamination and installation

• Reliance on workers' skill

The quality of the component finishes is dependent largely on the skill of the labour employed. The more experienced and competent worker will produce better quality workmanship. However in mass production e.g. in a large project where the same component is replicated, it may not be possible to ensure all workmen possess the same level of skill. Therefore the quality outcome may not be consistent since many workmen are deployed. As a result, the following workmanship issues are likely to surface due to lack of or variances in skill level:

- Imprecise cutting
- Air bubbles in lamination fixing
- Uneven lap or mitre joints.

Fig. 6.19 - On-site cutting relies on labour skill.

Fig. 6.20 - On-site lamination of carcass: Possible air bubble and blister defects.

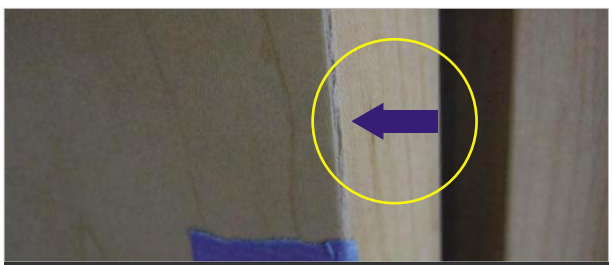


Fig. 6.21 - Poor jointing at turning in manual installation.

• Working space constraints

Very often, the installation work has to be carried out in narrow or confined spaces. The confined space is not a favourable environment for the workman to carry out fine or precision work. This may be compounded where there are many trade activities in the same area. In such situations, lower quality workmanship and productivity are often the result.

• Site environment

If the site environment is dusty or polluted, it may affect on-site lamination process. There is possibility of de-bonding, blistering and the finish surface may not be sufficiently smooth. At the same time, it is also necessary to take precautions during installation to avoid damage to other 'sensitive' finishing trades like natural stone or timber flooring.

• Layout and specifications

The more complicated the layout e.g. more turns, corners, odd shapes, etc. more care and in-depth planning is required before producing shop drawings. The installer should be capable of reading, interpreting and executing the designs according to the specifications. A proper cutting schedule needs to be prepared and adequate skill is required to assemble the works to minimize wastage during on–site installation.

Fig. 6.22 - A typical on-site installation environment.

Fig. 6.23 - Turns and odd shapes: Need more attention.

• Handling and storage

Materials can be easily damaged if they are not properly stored and protected against dust or wet and damp conditions. For certain products, improper storage and insufficient ventilation may affect the moisture content of the material leading to warpage and twist.

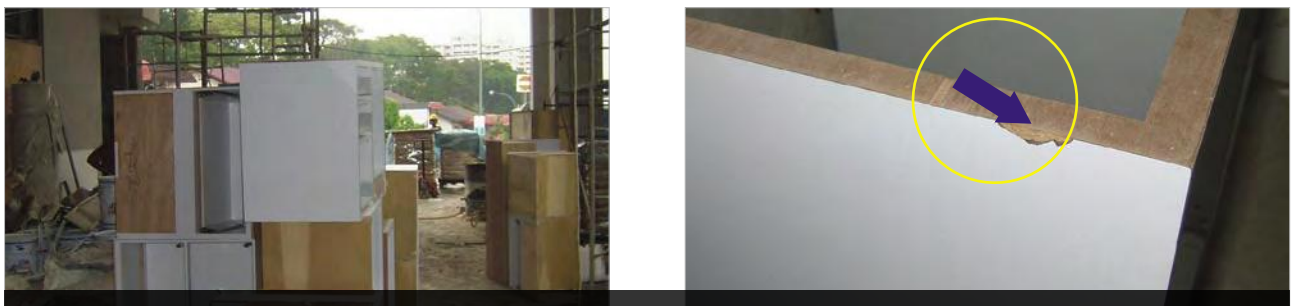


Fig. 6.24 - Damage caused by improper storage and other trades

6.2.2 Advantages of factory assembled components

• Smooth joints and finish

Factory assembled components generally have consistent joints and smooth finish especially in critical areas like rounded edges and mitre joints. The factory environment with good quality control results in better and more consistent component quality compared to on-site fabrication and assembly.

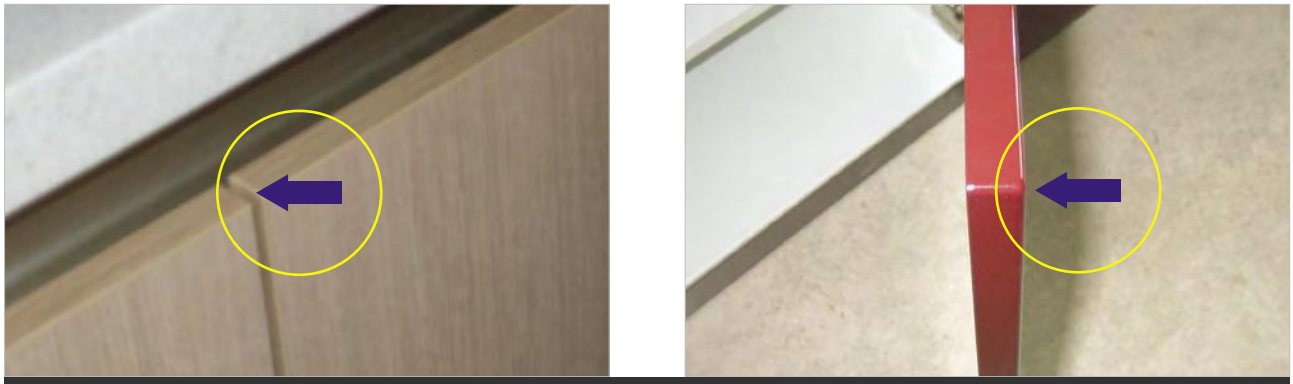


Fig. 6.25 - Joints at turns are smooth and precise in factory assembled cabinets.

• Less manpower on site

The factory environment favours producing components with good dimensional accuracy. The carcass and door panels are produced in standard sizes and no further alteration, trimming or alignment adjustment is required. Therefore, the components can be installed on site faster and with less manpower.

Fig. 6.26 - Less installers required when using pre-assembled components.

Fig. 6.27 - Pre-assembled modular kitchen cabinet system generally gives good finish, quality and dimensional accuracy.

6.2.3 Examples of component design and detailing for quality

To maximize the benefits of using factory assembled components, it is necessary to pay attention to design and detailing when installing the components on site. The following examples show how such benefits can be maximized.

• Using strips on joint between cabinet and wall

The traditional way of mounting a cabinet on a wall is by drilling and plugging. The small gap between cabinet and wall is then filled with silicone material. If the quality of silicone used is inferior, it will deteriorate and discolour with time. The jointing consistency will also depend on the skill of the applicator. If the gap between wall and component is too wide or inconsistent, the operation becomes more difficult. Very often this results in a joint that is not neat and aesthetically pleasing.

To overcome this, a PVC / rubber strip insert is placed at the joint instead of silicone infill in some modular system cabinets. It results in a neat, simple and consistent joint.

Fig. 6.28 - Gap between wall and component sealed by silicone material applied manually.

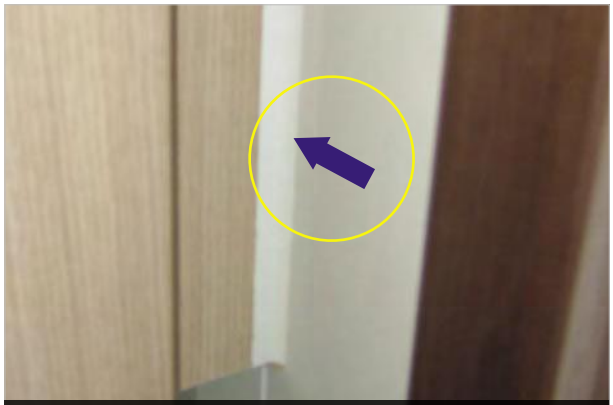


Fig. 6.29 - A PVC strip introduced in the gap results in consistent and neat finish.

• Additional hinges and magnetic catches for taller doors

In hinged swing cabinet doors where the door height is taller than usual e.g. 2.5m, it is good to provide additional hinges and magnetic catches to hold the heavier door panels in place. This prevents sagging and the door panel is held in position and aligned with the door frame. In addition, if there is any minor warping on the panels, the appropriate catch system makes it less noticeable.

Fig. 6.30 - A small warp becomes more noticeable in taller door panels.

Fig. 6.31 - Additional magnetic catches help to hold the door in position for taller panels.

• *Cushion in-lay for carcass*

Some cabinet systems come with rubber/PVC in-lay on the carcass inner face. This has a cushioning effect preventing the door panel from hitting the carcass surface and reducing noise. It also prevents surface damage to the panel and the carcass resulting from repeated use. The gap between the panel and carcass is also neat and consistent.

Fig. 6.32 - Door panel hitting directly on carcass creates noise and may cause damage.

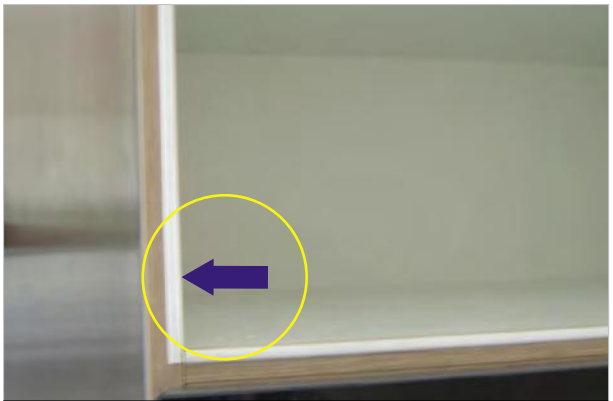


Fig. 6.33 - Provision of in-lay to carcass cushions against noise and prevents damage.

Fig. 6.34 - Gap between door panel and carcass is consistent and neat with in-lay.

• Rebate profile on component doors

In many cases, any warp in door panels becomes more noticeable when the adjoining gaps are wide. A rebated door panel profile can be introduced to make this less noticeable when the door is in closed position.

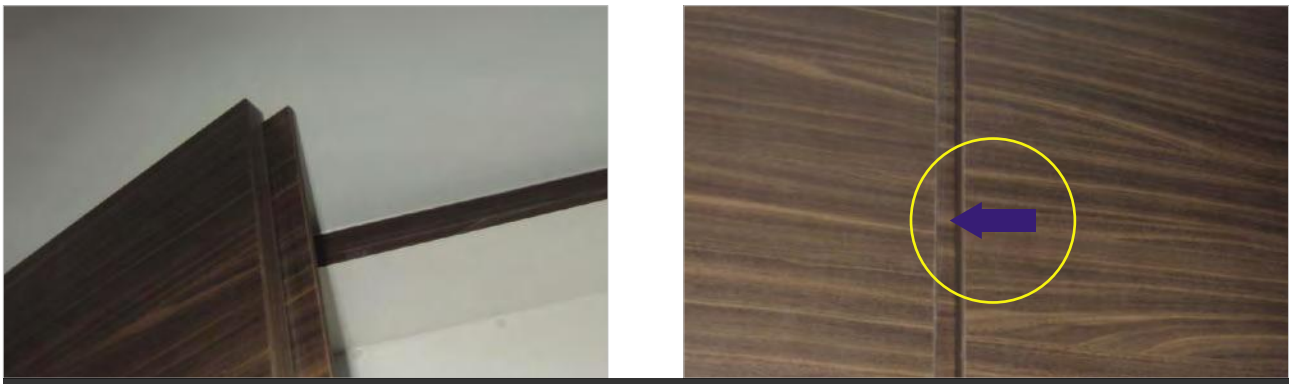


Fig. 6.35 - Door panels with rebate feature can make gaps better aligned and consistent.

• Joint -less counter top material

Some finishing materials like natural stone counter top have length limitations and joints have to be formed for continuity. In some designs, a backsplash of 75-100 mm height may be required and this needs to be joined with the counter top. All such jointing requires skilled installation to prevent liquid ingress and ensure a consistent smooth and flushed finish. It is also necessary to match the material at the joints to cater for inherent variations in quality like tonality, pinholes, porosity and texture.

Fig. 6.36 - Too many joints cause difficulty in ensuring smooth and flush finish.

To minimize such problems, some acrylic polymer materials that are suitable for counter tops and which come in long sizes together with backsplash can be used. The homogenous material generally has good resistance to liquid ingress and can be polished if there are any minor scratches on the surface. Less jointing is required and it gives a better quality finish appearance.

Fig. 6.37 - Long counter top with integrated backsplash: No on-site joint required.

Fig. 6.38 - Fewer joints facilitate easy installation and better quality finish.

• *Integrated components for less joints*

Wash basins are usually fixed to a vanity counter using a bracket system. The joints between the basin and counter top are then sealed with silicone material to prevent water ingress. Some projects eliminate this sealing process by using factory made integrated counter top with built-in basin and sink as a single component. This reduces site work and results in a uniform and quality finish.

Fig. 6.39 - Integrated vanity counter and washbasin.

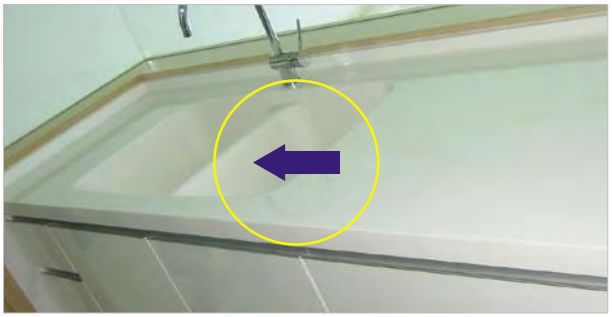


Fig. 6.40 - Integrated kitchen top, back - splash and sink.

To reap the benefits of high productivity and quality by using pre-assembled components, careful planning is required at the design stage. The plinths, kerbs, room dimensions and other spaces should be constructed accurately to suit the components. Once the components are fabricated, it would not be possible to alter or modify dimensions and sizes to suit changes in site conditions without additional time, cost and impact on quality.

7.0

DESIGN AND DETAILING FOR QUALITY AT ADJOINING LOCATIONS/ TRADES

7.0 DESIGN AND DETAILING FOR QUALITY AT ADJOINING LOCATIONS / TRADES

7.1 ARCHITECTURAL FINISHES

The design at adjoining locations i.e. where one architectural element meets another often has an adverse impact on quality, if little consideration is given as to how it is to be executed or maintained during use. Some designs are complicated and difficult to construct and may require more skill, planning and co-ordination among trades. Such designs should be reviewed at the shop drawing or mock-up stage and a simpler detail that facilitates construction and subsequent maintenance should be considered. The following examples illustrate such situations and suggest how the design and detailing can be modified to achieve better constructability and quality.

7.1.1 Adjoining door frame, wall and skirting

Generally, door frames are installed within the wall opening. However, when the frame is positioned too close to the adjacent wall running perpendicular to it, the gap between the wall and frame may become too narrow (about 15mm or less) and this may pose difficulty to complete the other finishing trades e.g. skirting, painting, etc. at this gap location (Fig 7.1 & 7.2). The same constraints will also occur when two adjoining door frames are positioned close to each other resulting in a narrow gap between them (Fig. 7.4).

Fig. 7.1 - Difficult to install skirting or carry out painting in the narrow gap.

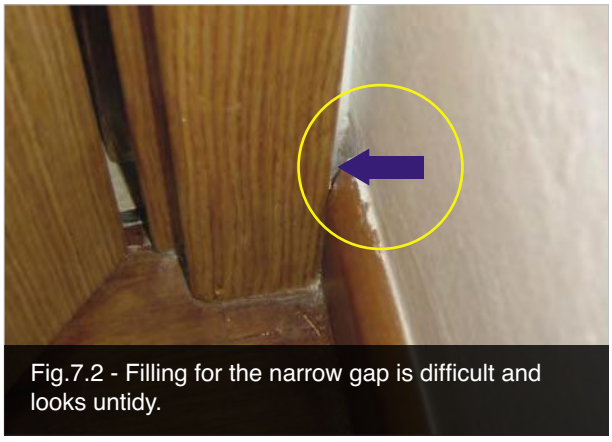


Fig.7.2 - Filling for the narrow gap is difficult and looks untidy.

Fig. 7.3 - Too small space: Difficult to seal by a skirting piece.

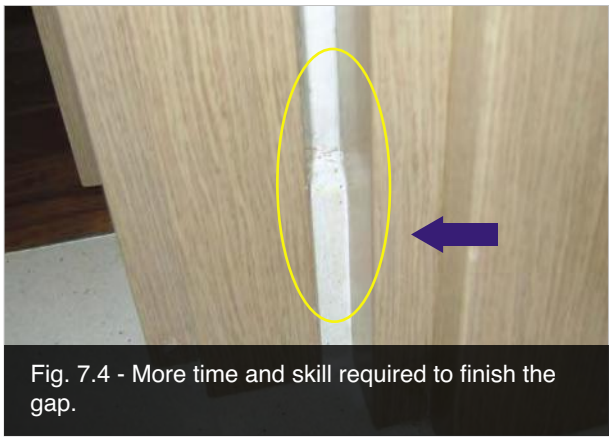


Fig. 7.4 - More time and skill required to finish the gap.

These situations can be avoided by positioning one side of door frame touching or very near the wall instead of leaving a gap. As the frame nearly touches the adjacent wall, any remaining gap can be easily filled with materials like silicone.

Fig. 7.5 - One side of the frame touches the wall and the other side has more working space. This facilitates execution of other finishing trades.

7.1.2 Architrave installation at wet areas

Some designs extend the architrave on door frames right to the floor. If this is located at wet areas like bathrooms, there is a high chance the architrave will absorb excess moisture leading to swelling, flaking of surface and damp rot over time.

Fig. 7.6 - Door architrave terminates on the wet area floor: Potential water contact.

To prevent such situations, the architrave should terminate above the floor level e.g. at threshold level. It is also good practice to install sub-frames above the screed level to reduce the chance of water ingress from the wet floor through the masonry works.

Fig. 7.7 - Sub-frame is installed above screed to avoid rising damp.

Fig. 7.8 - Architrave terminates at threshold to minimize water contact.

7.1.3 Timber floor near wet areas

It is common in residential units for wet and dry floors to be finished with dissimilar flooring materials e.g. the toilets can be finished with marble or stone tiling and bedrooms use timber flooring. If the drop at the interface between these functional areas is insufficient, there is the possibility of water ingress, thereby causing damage to the timber floor. Water ingress can also occur when wet areas are graded to falls, and the drop can be shallower at certain locations at the interface. Inadequate detailing or improper application of waterproofing membrane at the interface also increases the risk of water ingress.

Fig. 7.9 - Timber floor near toilet: Insufficient drop can increase chances of water ingress.

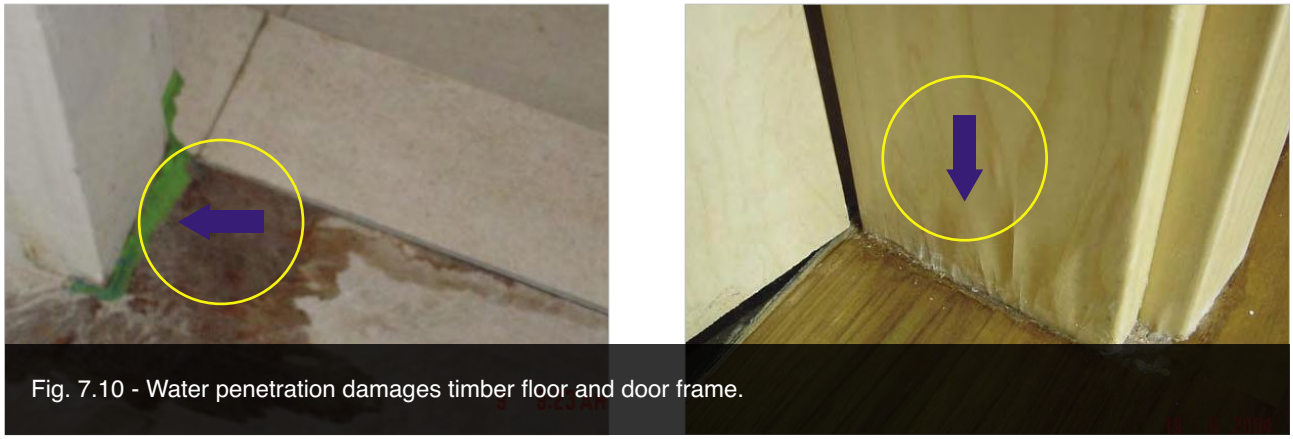


Fig. 7.10 - Water penetration damages timber floor and door frame.

To minimize such occurrences, sufficient drop should be provided during the structural works. In addition, the kerb at the junction should be properly treated with waterproofing material (Fig. 7.13). An extended stone threshold (Fig. 7.11) can also be employed to prevent water ingress, but the difference in flooring material will be noticeable when the door panel is in a closed position.

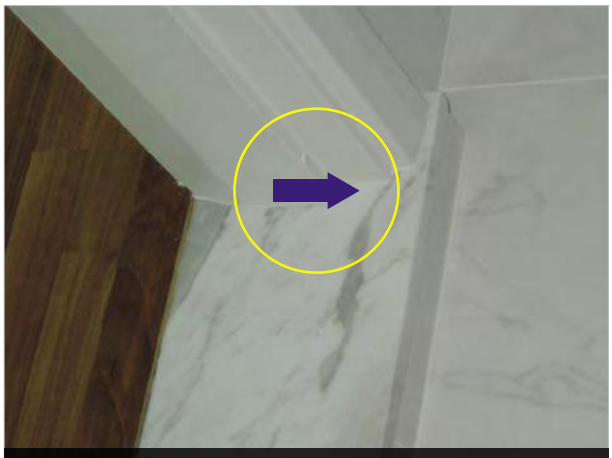


Fig. 7.11 - Sufficient drop and extended threshold: Possible ways to reduce water ingress.

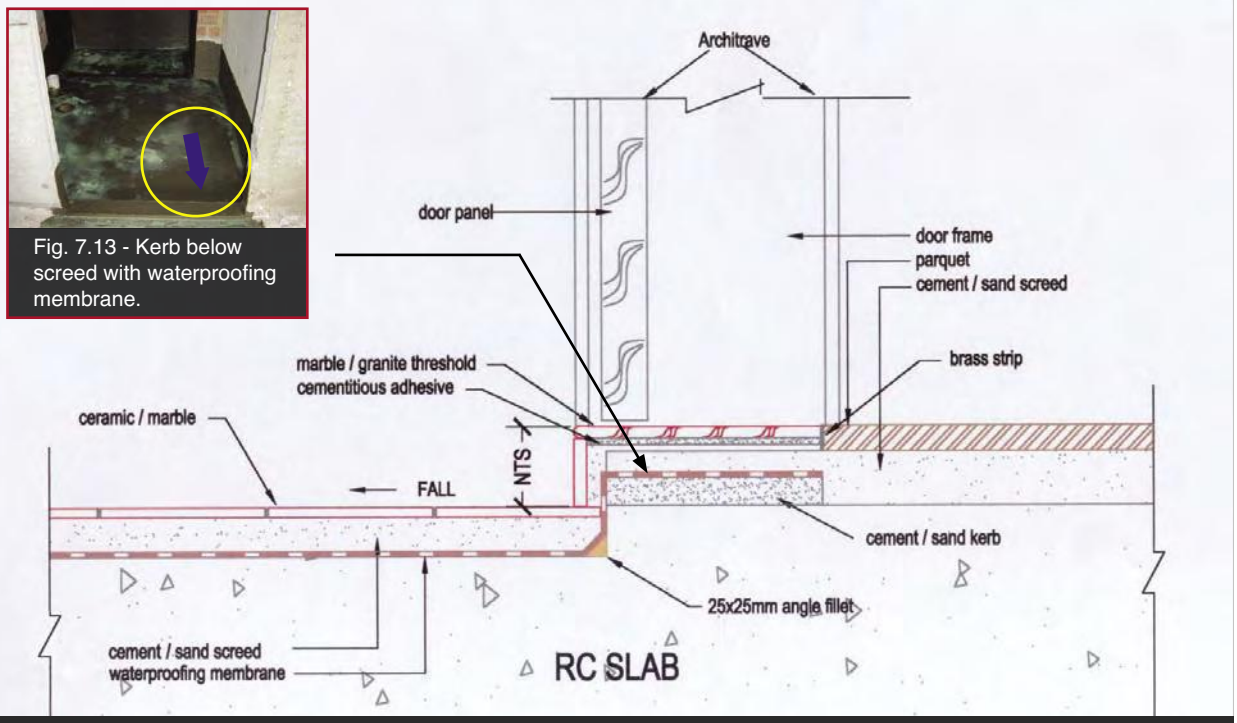


Fig. 7.13 - Kerb below screed with waterproofing membrane.

Fig. 7.12 - A small kerb below the screed may reduce water ingress.

7.1.4 Window frame and wall off-set

In some designs, window frames are positioned in the middle of a wall. This is to divide the wall with equal off-sets internally and externally. However when the off-sets are too narrow, it may be difficult to carry out the finishing works like plastering or tiling. Angle beads are usually provided to get a straight edge plastering and a vertical line. As it is not possible to install angle-beads around the window, it would be more difficult to achieve a quality plaster finish. Furthermore, if the surfaces are to be tiled, it would be more time consuming and labour-intensive as the tiles need to be cut to fit the narrow off-set width.

Fig. 7.14 - A narrow off-set around the window: More difficult to carry out plastering or tiling works.

These difficulties can be overcome by proper positioning of the window frame. For example, if there is a sunshade or canopy at the external face, the frame can be fixed flush with the external surface of the wall. This will leave a wider off-set on the inner recess of the wall where the finishing works can be more easily carried out. Alternatively, the frame can also be flushed with the internal wall finishes to facilitate works on the external off-set.

Fig. 7.15 - Window frame flush with one face of wall creates wider off-set to facilitate subsequent works.

7.1.5 Groove between floor and wall

Instead of skirting, some detailing provides a small running groove (about 20mm x 20mm) along the base of walls. It may be difficult to maintain dimensional consistency of such grooves particularly in a project with many units with such a design. This becomes more challenging to construct if the layout has many turns and tight corners or where the grooves are to be formed on masonry works.

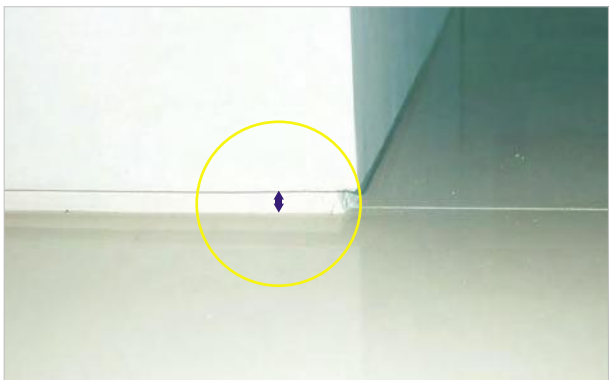


Fig. 7.16- A groove line between wall and floor instead of skirting.

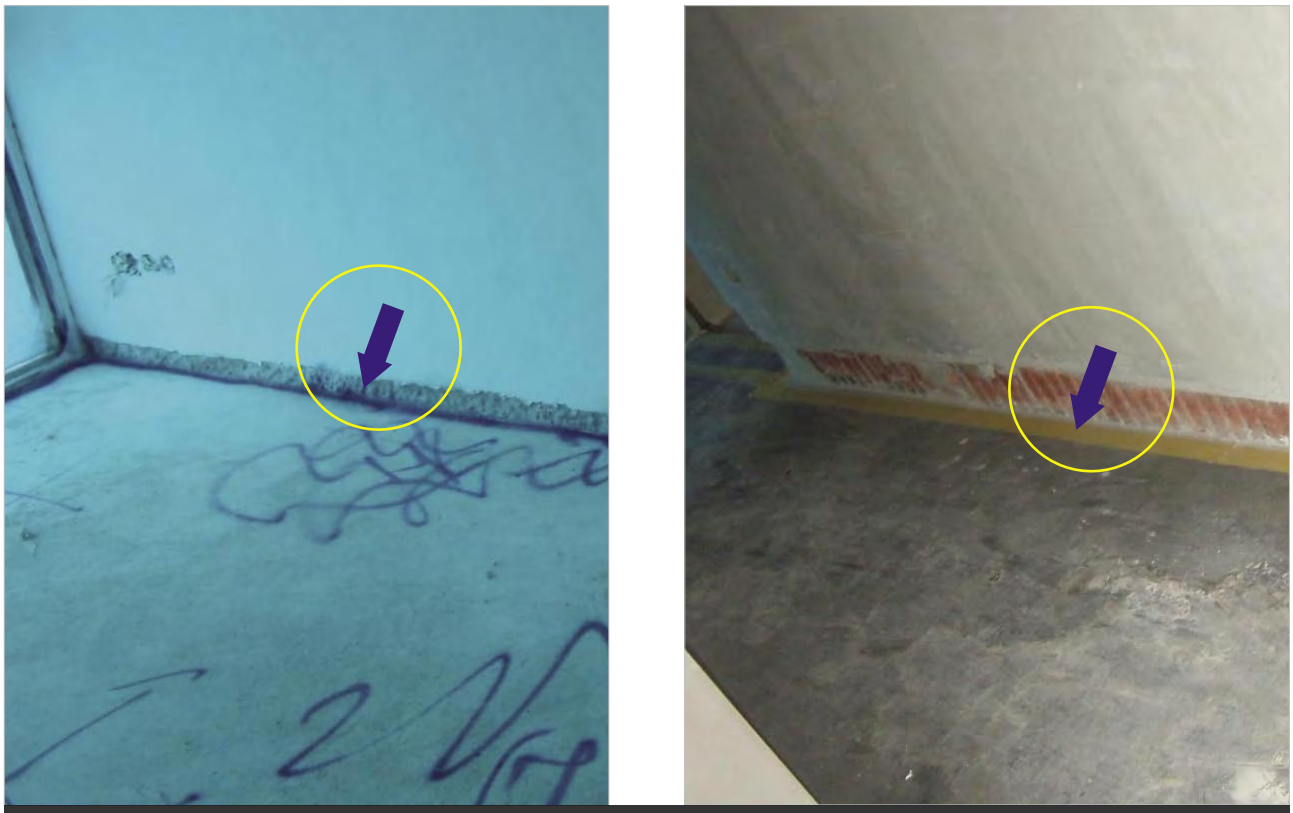


Fig. 7.17 - Forming grooves on masonry works: Challenging and time-consuming to maintain consistency.

Skirting can be considered to avoid such complications. Timber skirting is one of the options to cover joint between floor and wall and offers the following advantages:

- Long pieces of timber permit less joints on the skirting.
- Dry installation (by glue and nailing) can be employed and the small gap between the wall and skirting can be sealed by silicone material.
- Skirting can be installed after completion of floor polishing.
- Ease in installation.
- Consistent and better finish quality.

Fig.7.18 - Marble flooring with timber skirting: No wet works required for skirting installation.

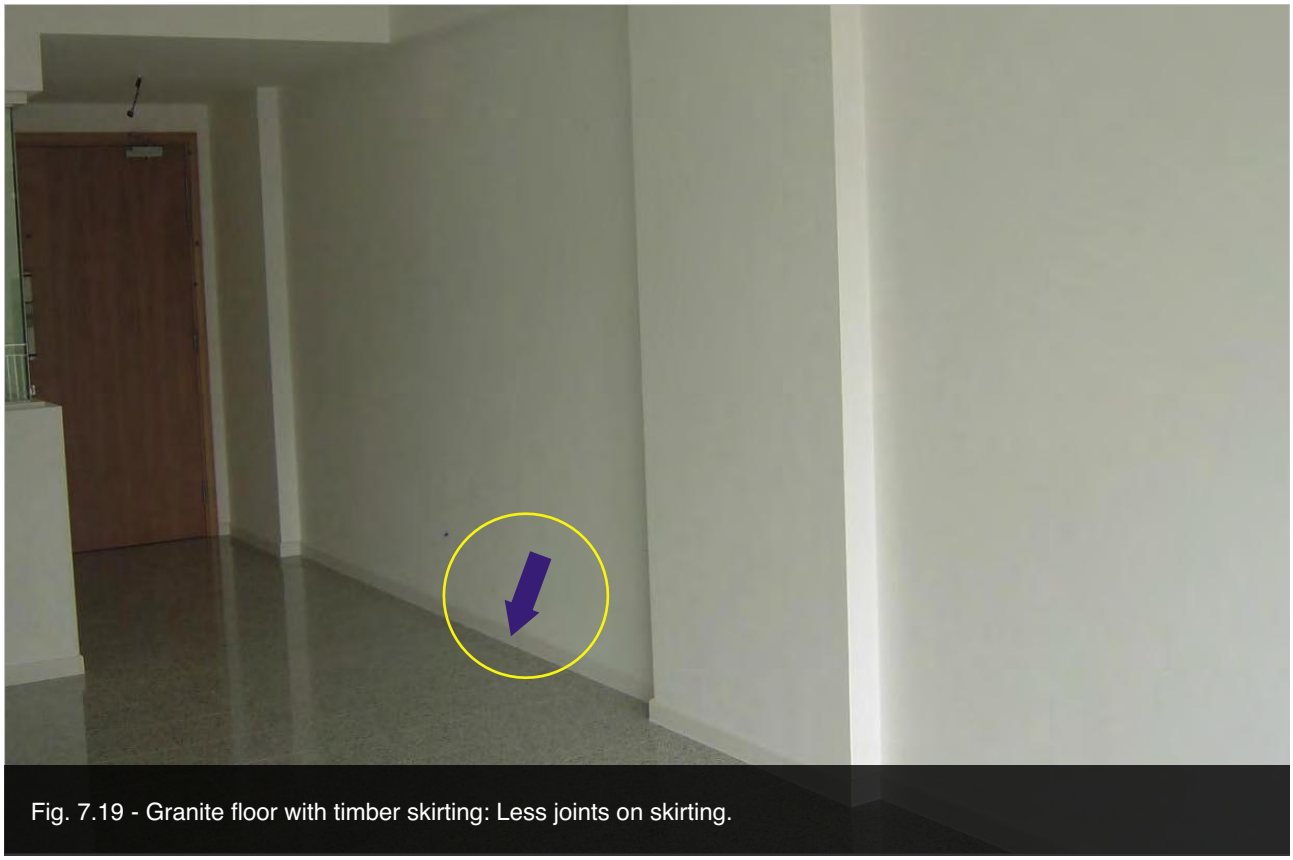


Fig. 7.19 - Granite floor with timber skirting: Less joints on skirting.

7.0 DESIGN AND DETAILING FOR QUALITY AT ADJOINING LOCATIONS / TRADES

7.1 ARCHITECTURAL FINISHES

Good interfacing design and detailing not only address quality issues but also facilitate constructability and minimize maintenance difficulties. However, to derive maximum benefit, a thorough review of interfacing design and detailing should be done early during the shop drawing or mock-up development stage.

Building services that are to be embedded or concealed should be properly planned and coordinated with other structural and architectural works to ensure they are functional and aesthetically pleasing. The locations and interfaces of the services with other trades should be determined early to avoid undesirable consequences during construction and maintenance. The examples below highlight some practices in positioning, concealing or embedding service pipes, their weaknesses and deficiencies, and some practical measures to overcome them.

7.2.1 Floor trap and sleeve coordination

For aesthetic reasons, floor trap grating cover is aligned with tile joints (Fig.7.20). To achieve this, proper tile setting out and the sleeve position must be well coordinated. If the pipe sleeve position is not directly below the grating cover opening, the floor screed or the concrete slab needs to be hacked to align it, otherwise the opening may be partially covered or “half moon” position (Fig.7.21). This will affect liquid flow, full functionality and maintainability. Further, the partial opening makes it difficult to install any additional fittings like mosquito or cockroach traps (Fig. 7.22).

Fig. 7.20 - Floor trap grating cover is aligned with tile joints for better aesthetics.

Fig. 7.21 - “Half moon” position affects liquid flow, functionality and maintainability.

Fig. 7.22 - Additional traps cannot be installed if sleeve opening is partially blocked.

• Causes of sleeve misalignment and partial opening

The common reasons for sleeve misalignment are:

- Inaccurate installation of sleeves during structural works stage,
- Misalignment of partition walls during its erection,
- Increase in basecoat plastering thickness in wet areas, and
- Incorrect setting-out of tiling works.

Dimensions and locations of floor traps and sleeves can be clearly defined in shop drawings. However, with many different trades involved during construction, it may not be possible to achieve accurate positioning unless there is sufficient planning, coordination and strict control during construction.

Accurate alignment is made more difficult when the concealed sleeve is the same size as the grating opening, which leaves no margin for any error. This challenge becomes more acute in large scale operations and where heavy reliance is placed on skilled labour to ensure consistent positioning.

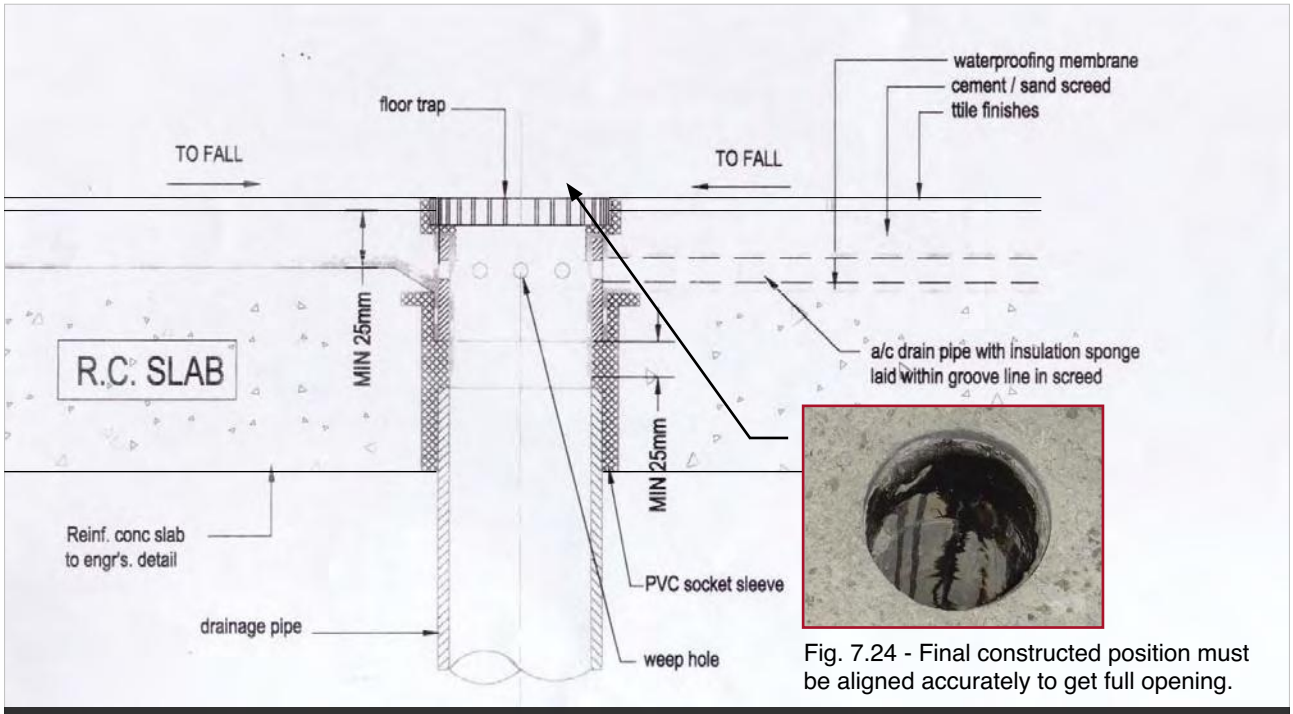


Fig. 7.24 - Final constructed position must be aligned accurately to get full opening.

Fig. 7.23 - Sleeve is exactly as grating opening size i.e. 100mm.

• *Enlarged sleeve system*

To overcome the challenge, a sleeve larger than the grating's opening can be considered. It gives some tolerance (about 15mm) all round for errors in positioning. This also provides flexibility in aligning the floor trap grating cover with the sleeve to achieve the full pipe opening without hacking the screed or concrete.

Fig. 7.25 - Funnel shaped cast-in pipe/socket sleeve.

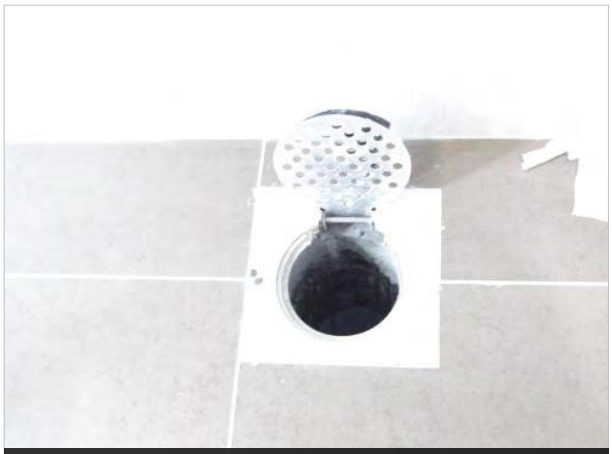


Fig. 7.26 - Flexibility in achieving full opening.

7.2.2. Provision of concealed floor pipes

• *Concealed in floor screed*

Discharge pipes leading from fittings to floor traps are often designed to be concealed in the floor. For proper flow and discharge, they have to be sufficiently sized and installed with a gradient. If such pipes are not properly integrated during construction, they have to be installed after the concrete slab has been cast. The concrete slab surface has to be hacked to a certain depth to receive the pipe. The usual size (diameter) of the pipe is 40mm or more and it is not possible to provide a full recess in the slab without affecting the reinforcement cover. Hence the maximum recess can only be about 15 to 20mm. The rest of the pipe protrusion will need to be concealed within the cement- sand screed. As the screed needs to slope towards the floor trap, it will be thinner near the floor trap and may not fully cover the protrusion of the pipe.

Eventually, any pipe protrusion not concealed by the screed will be covered by tiling adhesives. This means some portions of the tiles are directly resting on the pipes without a screed base. Such areas have weak bonds resulting in hollowness in the floor tiling.

Fig. 7.27 - Washing machine drain pipe of 40mm diameter connects to floor trap.

Fig. 7.28 - Screeding may not fully cover pipe protrusion due to forming gradient.

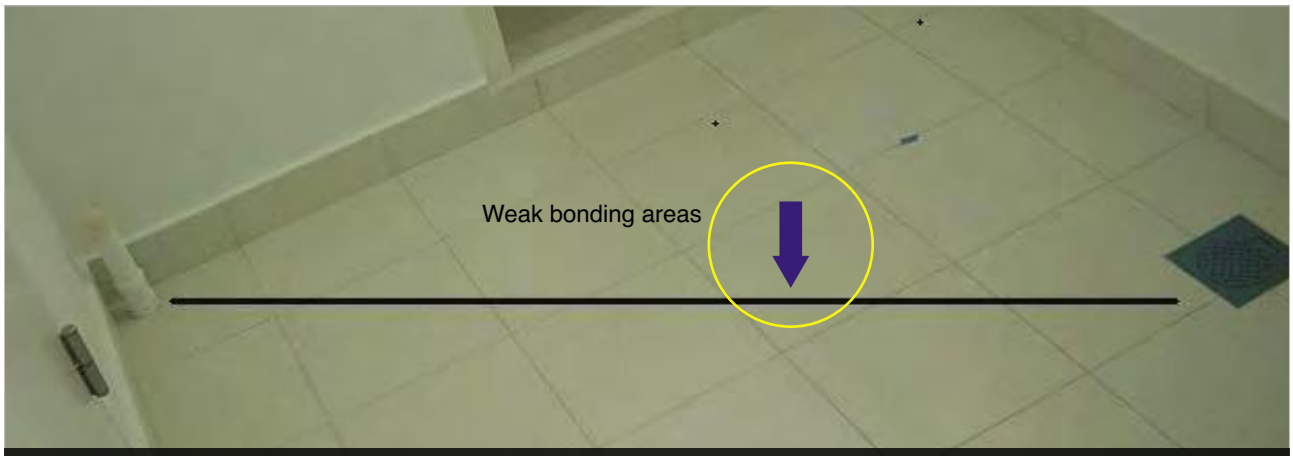


Fig. 7.29 - Weak bonding of tiles on top of pipe protrusion.

• *Embed into concrete slab*

To minimize such undesirable consequences in concealing pipes after concrete casting, pipes sleeves could be embedded with concrete casting. This requires proper planning and co-ordination to integrate the sleeves with the reinforcement before casting.

Fig. 7.30 - Floor trap sleeve with pre-arranged drain pipe provisions: Embedded into concrete slab

The advantages of embedding sleeves include:

- Avoid additional operations like trimming for recess, installing pipe, spot screed and waterproofing below pipes,
- Avoid thin screeding near floor trap,
- Avoid de-bonding of tiles,
- Avoid potential damages when the end-user decides to re-tile in future, and
- Single application of waterproofing system on the floor

Fig. 7.31 - Concealed sleeves with pipes after casting.

Fig. 7.32 - No risk of de-bonding of tiles on fully embedded pipes.

7.2.3 Positioning of discharge pipes

Discharge pipes (eg. washing machine discharge) are usually placed near wall corners to maximize working space. In some circumstances, due to increase in plaster thickness, misalignment of wall or inaccuracy in sleeve installation the sleeve position becomes too close to the wall. This will hinder or obstruct other architectural works like floor skirting, wall painting, applying sealant, etc. in its vicinity. This can be minimized by positioning the pipe a short distance away from the walls.

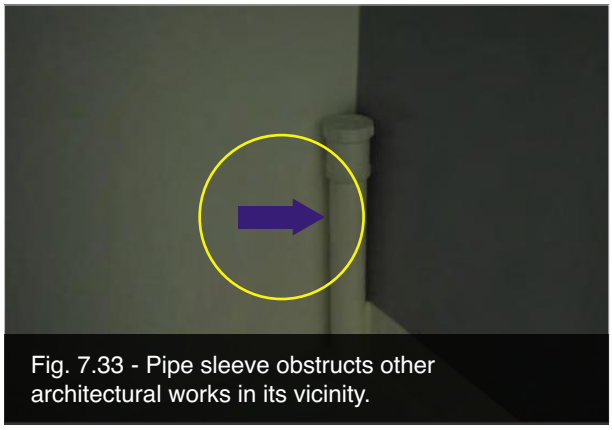


Fig. 7.33 - Pipe sleeve obstructs other architectural works in its vicinity.

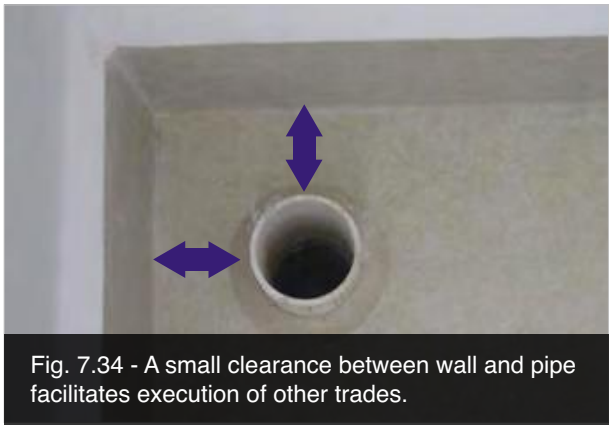


Fig. 7.34 - A small clearance between wall and pipe facilitates execution of other trades.

7.2.4 Concealed pipes in walls

Hacking of brick or block walls is often required for installation of concealed pipes especially in wet areas. This weakens the wall construction and may lead to water seepage if the patching up is not done properly.

Careful planning and proper sequencing of works should be adopted before and during the erection of walls. Concealed pipes with proper support should be installed prior to the erection of the wall. The wall should be stopped a short distance from the pipes as shown in the Fig. 7.36. A connector and mesh reinforcement can be used to provide further stability to the wall. After a few days, the opening can be sealed with concrete and simple formwork. This will ensure strength and better water-tightness in the wall.

Fig. 7.35 - Hacking brick walls weakens its strength and may lead to water seepage.

Fig. 7.36 - Concealed pipes are erected before construction of brick walls.

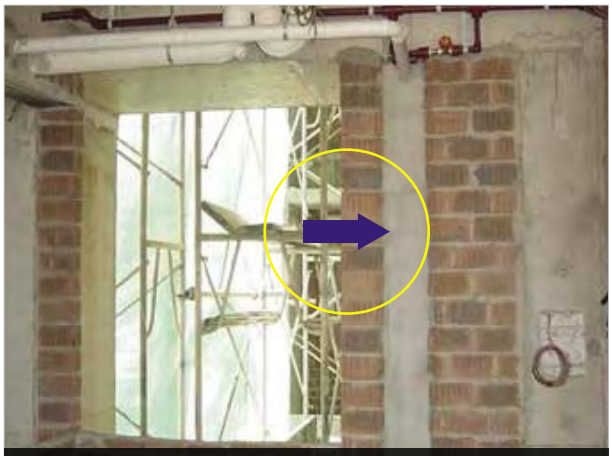


Fig. 7.37 - Pipe cast with concrete to ensure strength and water-tightness.

7.2.5 Routing of air-conditioning drain pipes

Air-conditioning drain pipe design usually starts with the pipe from the FCU (Fan Coil Unit) passing through a wall and floor slab to a wet area floor trap. The vertical and horizontal pipes are concealed in the wall and floor screed. As a gradient is required in wet floor areas, the screed often becomes thinner nearer the floor trap. This may result in de-bonding of floor tiles near to the floor trap (Fig. 7.29).

Similarly, where drain pipes pass over drops between wet and dry areas e.g. bedroom and toilet, the protrusion has to be covered by the screed and it will result in a shallower drop. This may lead to water ingress to the adjacent dry area.

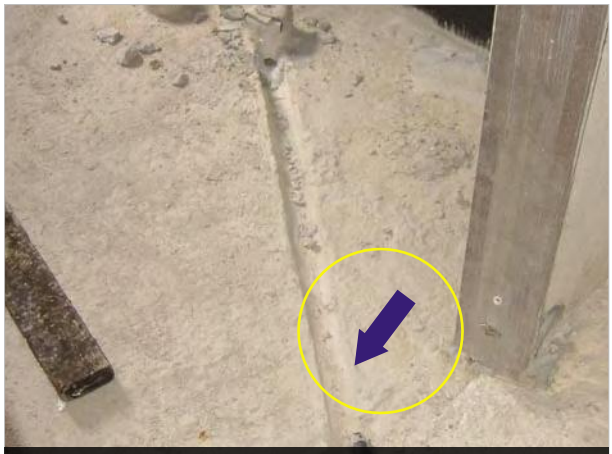


Fig. 7.38 - Running air-con drain pipes across drop leads to shallower drop.

Fig. 7.39 - Floor screed cannot cover high air-con pipe protrusion at floor trap.

• Rout air-conditioning drain pipes through ceiling to pipe shaft discharge

To overcome the challenge in routing drain pipes through floor slabs, one alternative is to run the pipes from FCU through the false ceiling and join to a pipe stack. To do this, careful planning is required at the design stage and there must be a false ceiling in the design.

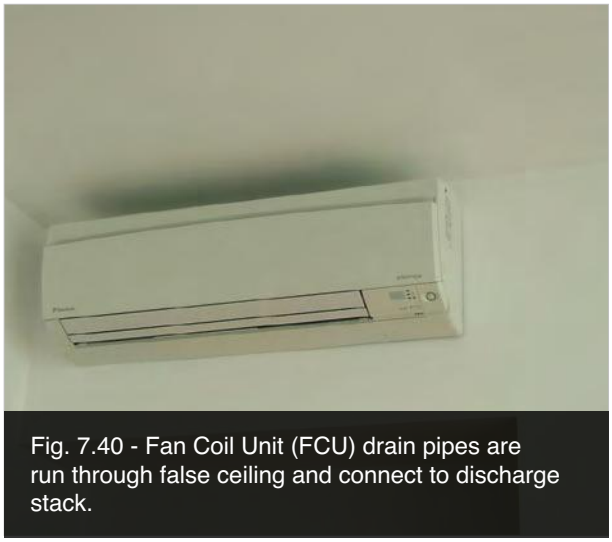


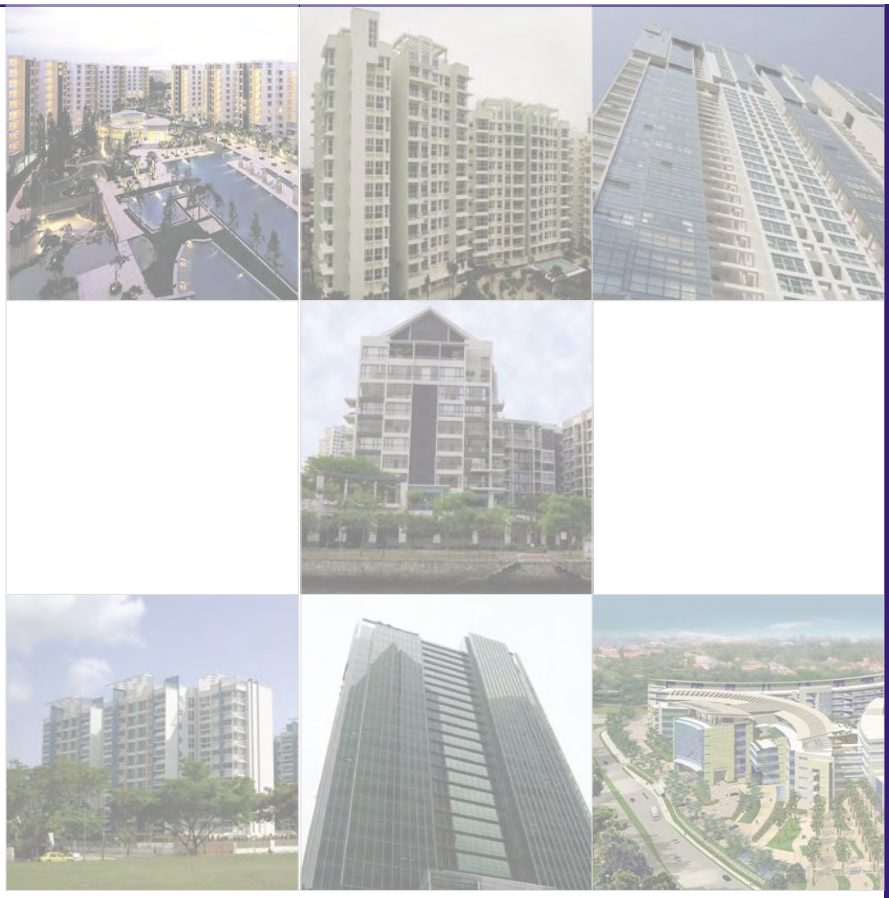
Fig. 7.40 - Fan Coil Unit (FCU) drain pipes are run through false ceiling and connect to discharge stack.

The drain pipes are to be properly supported and insulated before connecting to the discharge stack. It should be laid to an adequate gradient and tested before closing the false ceiling. A cleaning eye provision before the main discharge should be considered for maintenance purpose. The works should be properly sequenced and coordinated with other architectural works.

Fig. 7.41 - Drain pipes are properly insulated, supported and laid to required gradient.

Fig. 7.42 - Drain pipe connects to stack pipes above false ceiling.

The incorporation of embedded/concealed services requires careful planning at the design stage. Locations and interfaces of the services should be determined in the early stage of construction to avoid unpleasant consequences during construction and maintenance. The embedded services positions and routes should be properly documented in the as-built drawings for end-users' future reference and maintenance purposes.



8.0

EXAMPLE PROJECTS

The good design practices in this guide are based on observations of various projects with high CONQUAS/Quality Mark scores (Quality Mark Scheme is applicable only to residential projects). These projects invariably employ some or more of the good design and material selection practices in this guide to achieve better quality outcomes. Seven of these projects are highlighted here. It should be noted that the material for this guide also came from many other high scoring projects but due to space constraints, it is not possible to highlight all.

8.0 EXAMPLE PROJECTS

8.1 SAVANNAH PARK CONDOMINIUM

18 Blocks of 10-Storey Condominium Housing Development (Total 648 Units)

Prefabricated components:
Off-site production and better quality.

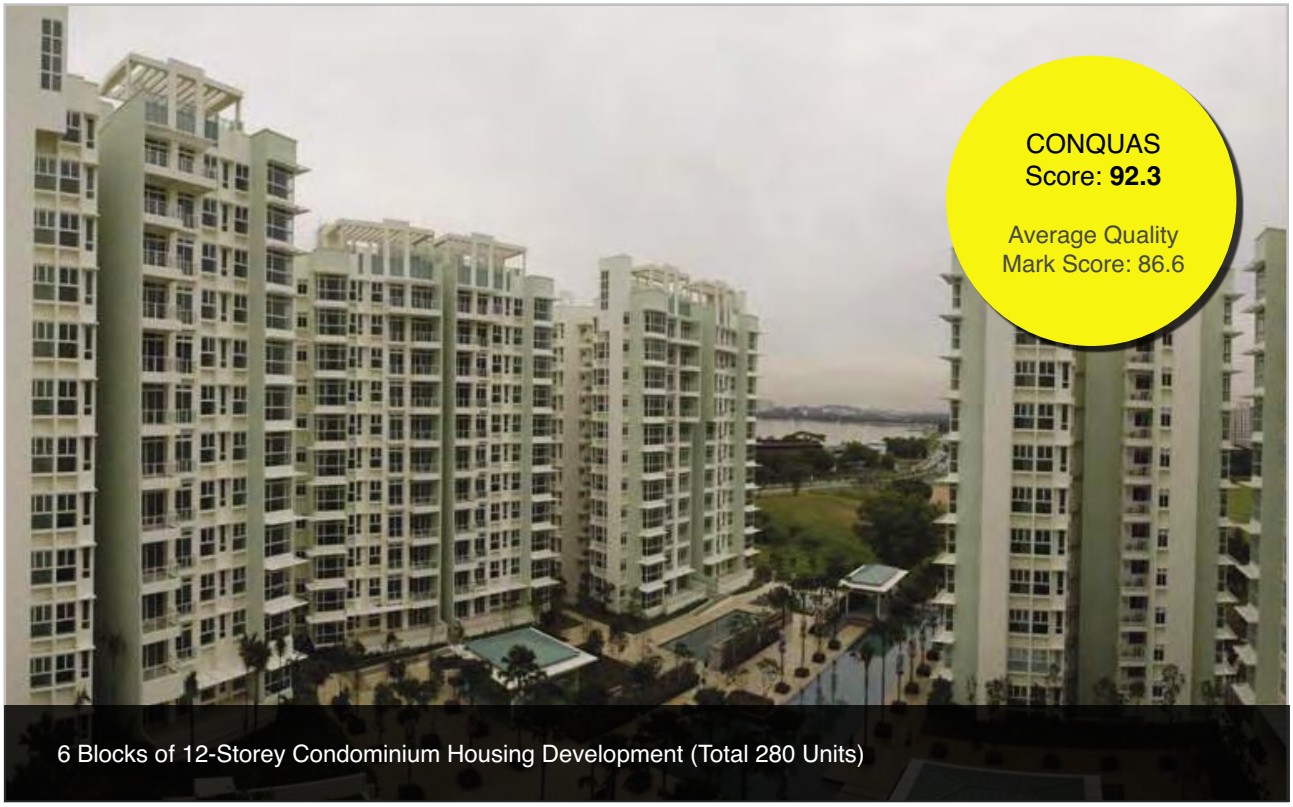
Precast planks:
Better flatness of floors.

Full height windows:
Minimize wet trades processes.

Drywall partitions:
Consistent flatness and finishing on walls.

Rebate door with lift-off hinges:
Good alignment of door frame & leaf.

Screed-less flooring:
Less de-bonding of floor finish.



6 Blocks of 12-Storey Condominium Housing Development (Total 280 Units)

Flat plate slab:
Flat surface, no internal beams.

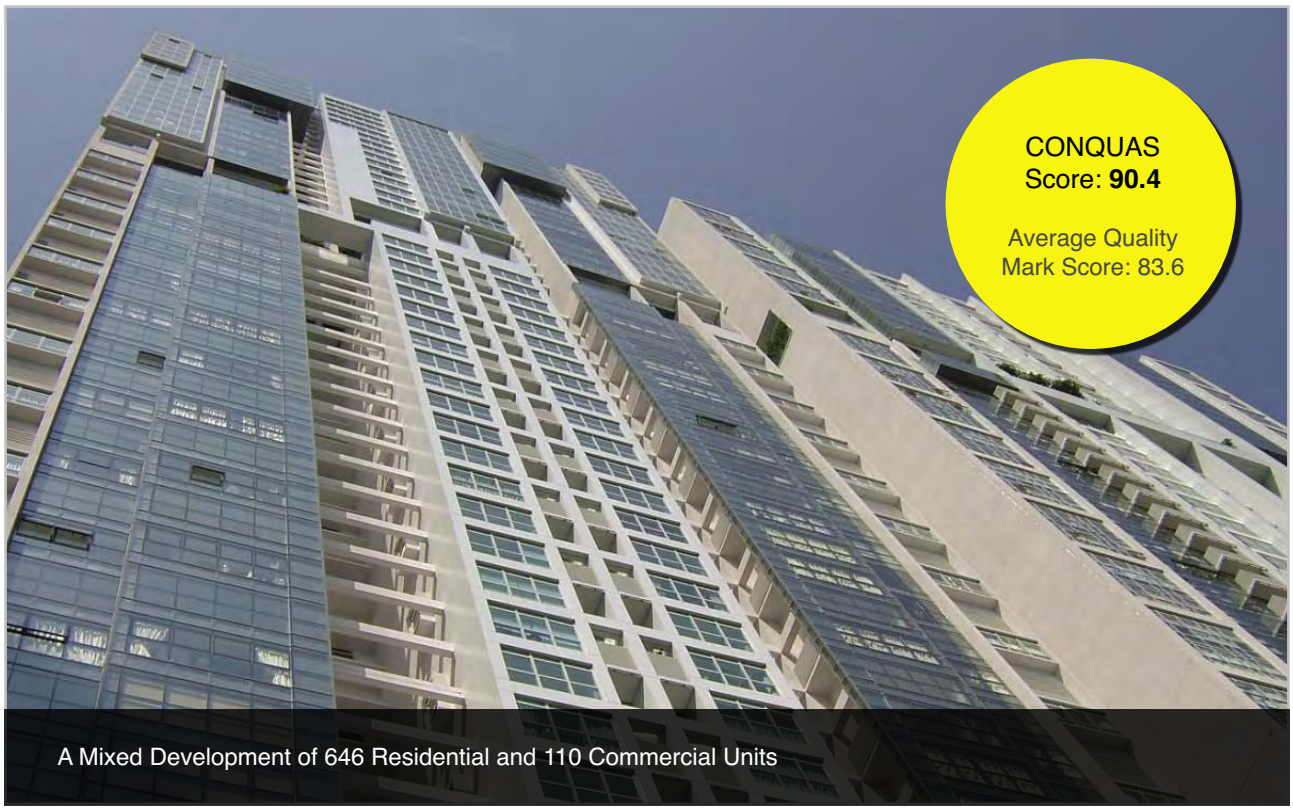
Precast facade:
Factory production, better dimensional accuracy.

Full height windows:
- Minimize wet trades
- No lintels required.

Light weight partitions:
Good control on alignment and evenness of finish surface.

Lift-off hinges door:
Facilitates late installation and reduce damages.

Sub-framed windows:
Easy to grout and better water tightness.



A Mixed Development of 646 Residential and 110 Commercial Units

DESIGN AND FEATURES FOR QUALITY

System formwork:
Better quality surface finish and buildabilty.

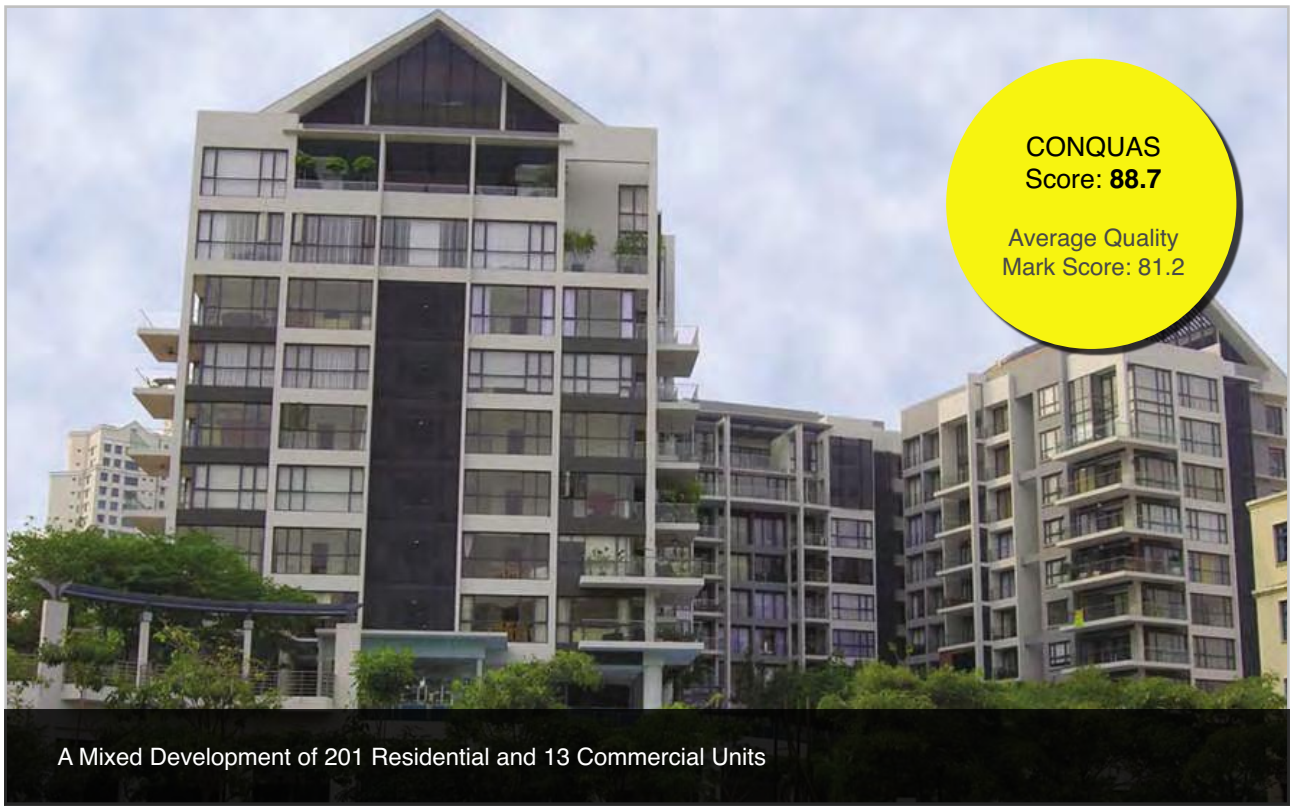
Flat plate slab:
Good surface finish and no obstruction for M&E works.

Engineered wood floor:
Pre-polished surface finish and consistent tonality.

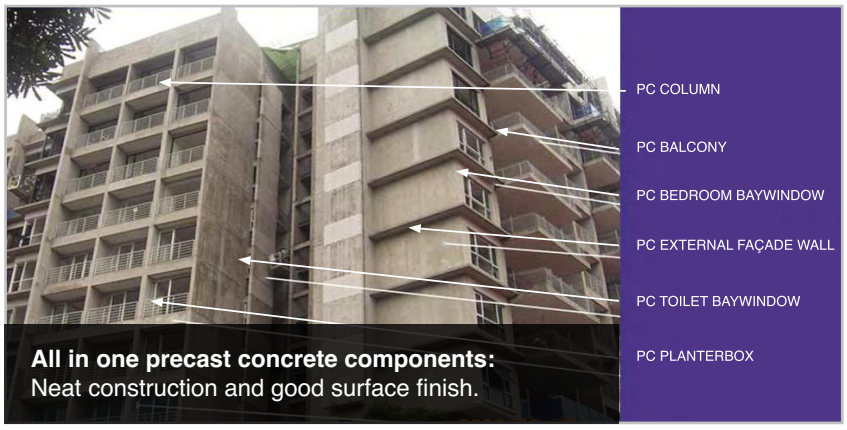
Sub-framed Door:
Minimize damages and neat joint on floor.

Full height windows:
Reduce wet trades and faster construction.

Click–fit sockets:
Installed after final painting.



A Mixed Development of 201 Residential and 13 Commercial Units



All in one precast concrete components:
Neat construction and good surface finish.

Precast planks:
No formwork required and good flat surface.

Drywall partitions:
Better quality finishes and ease of installation.

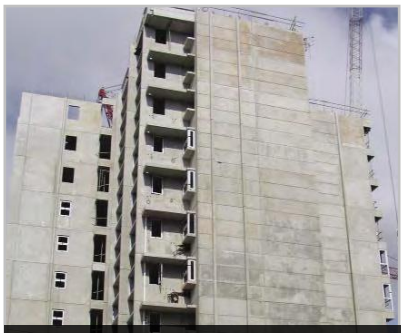
Lift-off hinges door:
Fast installation and better alignment.

PP-R (Polypropylenee Random Copolymer) pipes:
Ease of handling and no corrosion.

8.0 EXAMPLE PROJECTS
8.5 THE ESPARIS CONDOMINIUM

Five Blocks of 10-Storey Condominium Housing Development (Total 274 Units)

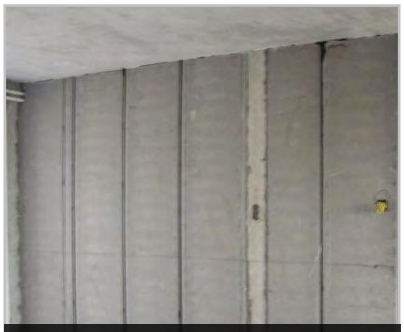
Precast components:
Better quality surface finish and good buildabilty.



Precast external wall:
No scaffolding and no plastering required.

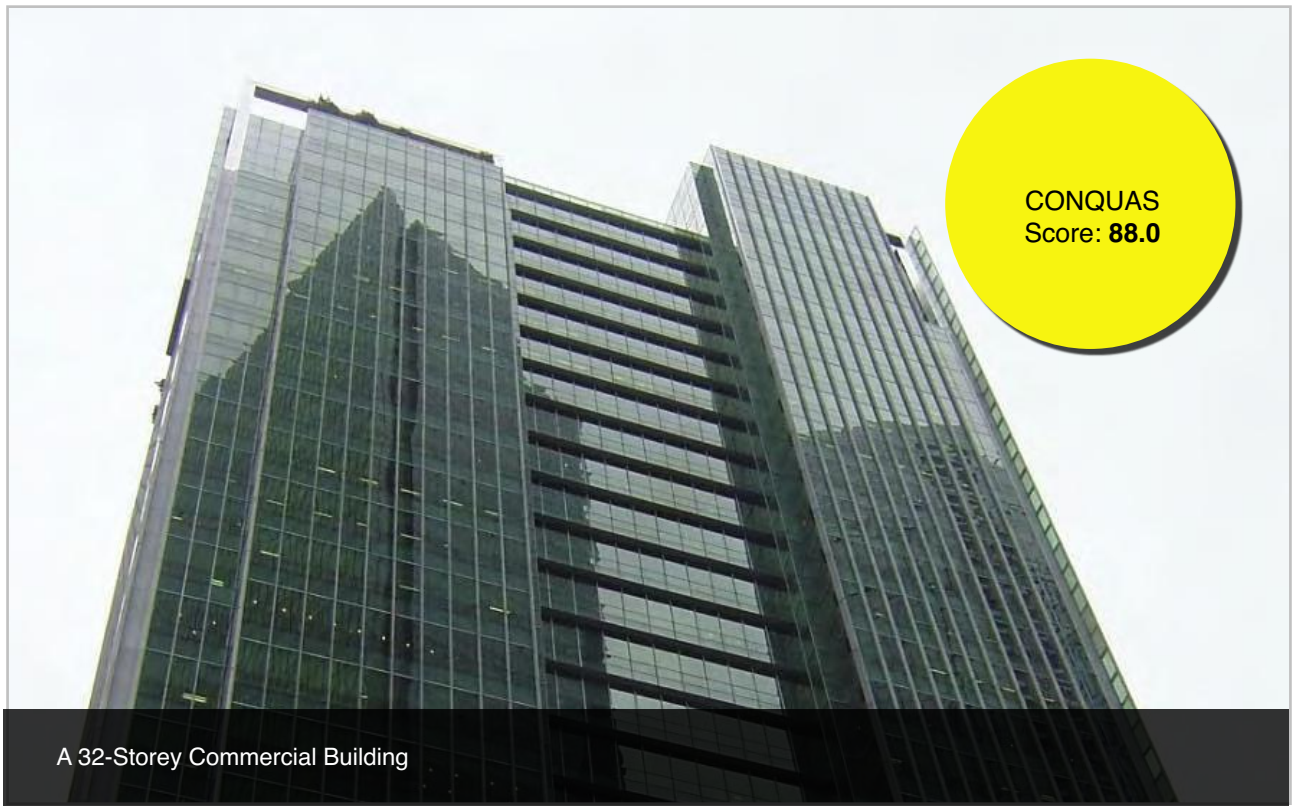
Flat plate slab:
No obstruction by internal beams and good surface finish.

Agglomerated stone flooring:
Consistent tonality and better quality finish.



Fine-wall (light weight) internal partitions: Fast installation and good alignment.

Sub-framed windows:
Controlled gap between wall and frame. Better water-tightness.



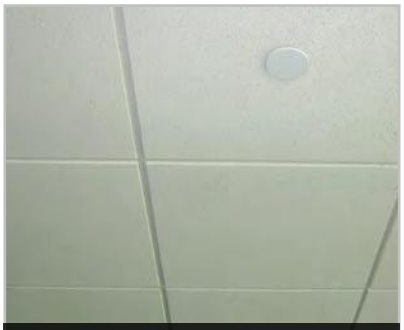
A 32-Storey Commercial Building

Column-free floor plate slab: Provides maximum clearance for other trades.

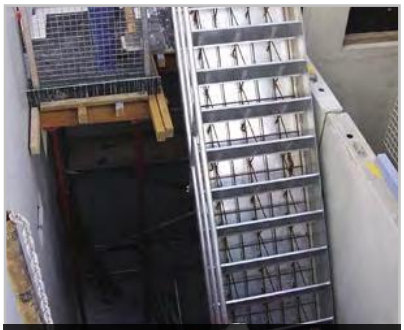
Post-tensioned beams: Ease reinforcement congestion.

Fully unitized glass curtain wall system: Off-site prefabrication speeds construction and brings up quality.

Modular raised floor system: Flexibilty to run M&E services.



Modular suspended acoustic ceiling: Uniform size and better surface finish.



Pre-fabricated stair formwork: Precise dimensions & good finish.

8.0 EXAMPLE PROJECTS

8.7 ITE COLLEGE EAST @ SIMEI AVENUE

ITE Campus Comprising Administration, Technology, Business and Sports Blocks

DESIGN AND FEATURES FOR QUALITY

Precast components:
Elimination of formwork and better quality finish.

Steel structures:
Superior in strength, flexibile in design.

Curtain wall claddings:
Accuracy in fabrication and ease of installation.

Drywall partitions:
Speed up construction process, better quality surface finish.

Raised floors:
- Flexible for M&E services
- No wet screeding.

Prefabricated steel stiffener:
Eliminates wet work and expedites process.

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