

Six Best Practices to Prevent Temporary Structure Failures During Construction

By **Ir. Dr Mohd Fairuz Ab Rahman**
Ts. Mohd Fiqri Mohd Hanafi
Ts. Nazruddin Mat Ali

Construction Safety Division, Department of Occupational Safety and Health

The six best practices on safety and health during concrete work to prevent formwork and falsework collapse, are derived from legal requirements and lessons learned from accident forensic studies carried out by the authors.

Recently, there have been several fatal accidents involving temporary structures, in particular during concrete works being carried out, which resulted in formwork and falsework collapsing at construction sites. These accidents have garnered widespread attention, and members of the public have expressed their concerns regarding the safety and health of occupational activities at construction sites. In many investigations of collapsed formwork and falsework, the authors found that there was insufficient consideration given to the safety management of these structures. So, it is important for all parties involved in a construction project, especially engineers who may work as project managers or designers of falsework, to understand their duties and responsibilities when carrying out this construction activity. This understanding must be clear, to differentiate between the duties and responsibilities stated in the legal requirements and the scope of duties in the contract requirements.

What is Temporary Structure?

Temporary structure or temporary work is commonly used in the construction industry to refer to an “engineering solution” used to support or protect an existing structure or permanent structure during construction, or to support a plant or equipment, or the vertical or slope side of an excavation, or to provide access. Most construction of permanent structures will use temporary structures. The *BS 5975 Code of practice for temporary works procedures and the permissible stress design of falsework* defined temporary structures as “those parts of the structures that allow or enable the construction of, protect, support or provide access to, permanent structures and which might not remain in place at the completion of the structures”.

Temporary structures include, but are not limited to the following:

1. Earthworks – for example, ditches, dredging, temporary slopes and sheet piles;
2. Structures – for example, scaffolding, formwork, falsework, struts, façade retention, needling, shoring, edge protection, temporary bridges, site hoarding and signage, site fences, cofferdams; and



Figure 1: In many investigations of formwork and falsework collapsed, the authors found that there was insufficient consideration given to the safety management of these structures.

3. Plant foundations or equipment – for example, tower crane foundations, supports, anchors and ties for hoists and mast climbing work platforms, groundworks to provide suitable locations for plant erection, such as moving cranes and piling rigs.

Statutory and Contractual Obligations

In essence, the duties and responsibilities set out in an employment contract must not be less than the scope of the statutory duties and responsibilities (prescribed in the legislation). Ideally, the statutory duties must be equivalent to the contractual duties, but if there are contradictions, the statutory duties must always supersede the duties written in the contract. This article to some extent briefly describes the

responsibilities of duty holders regarding the use of formwork and falsework as outlined by the OSH legislation, in particular, the *Chief Inspector Special Order No. 1 Year 2020 on the Safety Management of Temporary Structure (Scaffolding, Formwork and Falsework)* (“Special Order”). This Special Order makes it the duty of the manager, who is employed by the contractor in management or operation of scaffolding, formwork and falsework, to ensure their safety and health¹.

These duties and responsibilities are explained along with six best practices that need to be given special attention to by engineers and managers to prevent incidents related to the use of formwork and falsework. Besides the acts, regulations and special orders published and enforced by the DOSH, engineers (including PEPC) should also refer to publications by the Board of Engineers Malaysia (BEM), namely *Guidelines No. 001 The Role and Responsibility of Professional Engineers for*

¹ The Chief Inspector Special Order is published with a directive letter by the Director General of DOSH to all managers of construction sites. The directive letter can be accessed here: <https://www.dosh.gov.my/index.php/legislation/directive-letter/sa-2020/3729-surat-arahan-bagi-pelaksanaan-perintah-khas-ketua-pemeriksa-bil-1-tahun-2020-perintah-khas-ketua-pemeriksa-bilangan-1-tahun-2020-pengurusan-keselamatan-struktur-sementara-perancahan-acuan-dan-penyangga/file>



Figure 2: Formwork and falsework are “engineering solutions” used to support wet concrete to form permanent structures (for example, reinforced concrete columns, beams and slabs) during construction.

*Temporary Works During Construction Stage*² and the *CIS 23 Safe Use of Falsework in Construction by the Construction Industry Development Board (CIDB)*³.

Safety Issues

In essence, formwork and falsework are temporary structures used to support or enable the construction of permanent structures. The safety aspects of formwork and falsework during construction are generally covered under the Occupational Safety and Health Act 1994 (OSHA). The OSHA prescribes the general duties of the contractor as an employer to ensure that the falsework and formwork are safe for the workers, and provide the safe system of work (commonly known as method statement or safe work procedure) based on the risk assessment carried out during the planning and design phases

of the construction project. The safe work procedure must be fail-safe to ensure that workers are not at risk of injury.

The specific duty of the contractor on safe design and use of formwork and falsework is prescribed in the Factories and Machinery (Building Operation and Engineering Construction Works) (Safety) Regulations or BOWECS. The BOWECS Regulations indicate that falsework or supports, braces and other struts are part of the formwork. The Special Order is introduced to further explain the expectation of the law towards the manager of construction work, who is employed by the contractor, in relation to the safety management of formwork and falsework during construction. Any manager who fails to comply with the Special Order shall be guilty of an offence and shall on conviction be liable to a fine not exceeding RM200,000 or to imprisonment for a term not exceeding five years or to both.

² Available online at <http://www.bem.org.my/documents/20181/50002/GL+001+Temporary+Works.pdf/>

³ At the time of writing, this document is currently under review by CIDB.



**PERINTAH KHAS KETUA PEMERIKSA
BILANGAN 1 TAHUN 2020
PENGURUSAN KESELAMATAN STRUKTUR SEMENTARA (PERANCAH, ACUAN DAN PENYANGGA)**

Pada menjalankan kuasa yang diberikan oleh subseksyen 27(1) Akta Kilang dan Jentera 1967 [Akta 139], Ketua Pemeriksa Kilang dan Jentera mengeluarkan perintah khas yang berikut:

1. Dalam Perintah ini, melainkan jika konteksnya menghendaki makna yang lain:

- (a) **Pengurus** adalah orang yang diambil kerja dalam mana-mana perkhidmatan yang melibatkan pengurusan atau pengendalian bagi, atau penjagaan ke atas, atau kedekatan kepada, mana-mana jentera atau proses yang dijalankan dalam mana-mana tempat kerja;
- (b) **Orang yang ditetapkan** ertinya seorang yang kompeten yang dilantik oleh majikan untuk menjalankan apa-apa kerja penyediaan atau pemeriksaan atau melaksanakan apa-apa tugas atau kewajipan yang telah ditetapkan oleh Peraturan-Peraturan Kilang dan Jentera (Kendalian Bangunan dan Kerja-Kerja Binaan Kejuruteraan) (Keselamatan) 1986.

2. **Pengurus** hendaklah memastikan:

- (a) pelantikan Jurutera Profesional, orang yang ditetapkan dan pekerja-pekerja lain bagi menjalankan tugas-tugas yang dinyatakan di dalam Bahagian III dan X, Peraturan-Peraturan Kilang dan Jentera (Kendalian Bangunan dan Kerja-Kerja Binaan Kejuruteraan) (Keselamatan) 1986;
- (b) pekerja-pekerja yang dilantik di bawah Perintah 2(a), mematuhi kehendak perundangan;
- (c) prinsip-prinsip yang diakui umum tentang amalan yang baik dan selamat diamalkan;
- (d) sistem permit menjalankan kerja (*permit-to-work*) dilaksanakan;
- (e) penyediaan peruntukkan masa, bahan, bajet dan sumber lain yang sesuai dan mencukupi;
- (f) tiada perancah boleh digunakan sebelum diperiksa dan dipastikan selamat oleh orang yang ditetapkan; dan
- (g) dokumen dan rekod-rekod berkaitan struktur sementara (perancah, acuan, dan penyangga) dikemaskini dan disimpan di tempat kerja untuk tujuan pemeriksaan pada bila-bila masa.

3. **Pengurus** hendaklah memastikan bahawa Jurutera Profesional:

- (a) membuat apa-apa reka bentuk dan lukisan, ujian, pemeriksaan, penyediaan maklumat dan langkah-langkah pengendalian struktur sementara yang wajar; dan
- (b) menyelia pembinaan dan kestabilan struktur sementara yang direka bentuk olehnya adalah selamat.

4. **Pengurus** hendaklah memastikan bahawa orang yang ditetapkan:

- (a) memeriksa semua bahan yang digunakan mengikut standard yang ditetapkan, tiada sebarang kecacatan dan selamat untuk digunakan;
- (b) menyelia secara terus kerja-kerja struktur sementara mengikut reka bentuk yang ditetapkan semasa ia dibina, diubah dan ditanggalkan;
- (c) menyelia secara terus kerja-kerja penyanggaan semula struktur sementara secara menyeluruh mengikut reka bentuk yang ditetapkan;
- (d) menjalankan pemeriksaan secara menyeluruh ke atas struktur sementara semasa dan selepas pembinaan; dan
- (e) memeriksa perancah dalam tempoh setiap tujuh hari, atau setiap kali perancah terdedah kepada keadaan cuaca atau insiden yang mungkin menjejaskan keteguhan atau kestabilannya atau telah menyebabkan mana-mana bahagiannya teranjak.

Penalti

Mana-mana orang yang melanggar perintah khas ini adalah melakukan suatu kesalahan dan boleh didakwa di bawah seksyen 8(g) Akta Kilang dan Jentera 1967 [Akta 139] dan jika disabitkan kesalahan boleh didenda tidak melebihi dua ratus ribu ringgit atau dipenjarakan selama tempoh tidak melebihi lima tahun atau kedua-duanya.

HJ. IR. OMAR BIN MAT PIAH
Ketua Pemeriksa
Jabatan Keselamatan dan Kesihatan Pekerjaan
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Figure 3: The Chief Inspector Special Order No. 1 Year 2020 on the Safety Management of Temporary Structure (Scaffolding, Formwork and Falsework). Any breach of the Special Order carries a fine not exceeding RM200,000 or imprisonment for a term not exceeding five years or both upon conviction.



Figure 4: The safe work procedure prepared by the contractor and the PEPC must be fail-safe to ensure that workers are not at risk of injury while working with the formwork and falsework.

The temporary structures are usually designed by Professional Engineers with Practising Certificates (PEPC) appointed by the main contractor, and they commonly do not have a contractual relationship with the permanent structure designer—either the PEPC (different from the temporary structure PEPC) or the architect. The BOWECS Regulations require the design of falsework and formwork to be carried out by PEPC if:

1. the floor to ceiling height exceeds 9.14 metres;
2. the formwork deck is supported by shores constructed in two or more tiers; or
3. the dead, live and impact loads on the formwork exceed 732.2 kgf per square metre.

The BOWECS Regulations further requires the PEPC to be responsible for the supervision of the construction and stability of the falsework and formwork he designed. The PEPC is also required to prepare a specification (safe work procedure) for dismantling the formwork and falsework, and

dismantling works can only be carried out after his approval and in accordance with the safe work procedure.

Like other temporary structures, formwork and falsework are typically used in a short period compared to the entire duration of the project. Therefore, the accuracy of the design and installation may not be given special emphasis, as compared to the permanent structures. However, most formwork and falsework designs are based on the same principles used in permanent structures for lateral stability. Therefore, there is a significant knowledge and information gap between the permanent structure designer and the temporary structure designer.

Ideally, the designer of a permanent structure should pay attention and give due consideration to formwork and falsework so that the design of a building or its permanent structure can help the designer of a temporary structure design safe formwork and falsework or any other temporary structure. However, this situation is rare. Therefore,

the main contractor has an important role to play so that this knowledge and information gap can be avoided by ensuring that effective arrangements and management have been put in place to control the risks in the use of formwork and falsework.

Best Practice #1 - Knowledge and Experience

The first best practice is about appointing the right person, who has the skill, knowledge, training and experience to carry out the task. Besides the contractor, the BOWECS Regulations has designated two individuals who have to carry out the prescribed duties and responsibilities, namely the PEPC and the designated person (DP). The contractor should establish that the PEPC and the designated person have the suitable skill, knowledge, training and experience in aspects such as design, installation and use of formwork-falsework before appointing them. Among the knowledge that a PEPC must have is the appropriate design code. Likewise, any PEPC or DP seeking appointment as individuals should ensure they have the necessary skills, knowledge and experience.

The PEPC should also have appropriate experience and comes from the right branch of engineering. He must also be aware of the latest design code to be used for design. In the case of the DP's appointment, the contractor may consider anyone who is in the process of gaining the right training. Currently, the Master Builders Association Malaysia (MBAM) is offering Certification Training for Designated Person (DP) in Concreting⁴. If proprietary falsework is used, additional training may be required for the DP (Concrete) and workers.

Appropriate training should be provided to the designated person, and for concrete work, he or she may be known as the DP (Concrete). Among the training requirements for DP (Concrete) are design specifications, installation procedures, inspection and disassembly. In addition, the DP (Concrete) and workers should be trained so that they are aware of the risks and understand the safe work procedures that have been established by the contractor. Some generic hazards arising from formwork and falsework usage are:

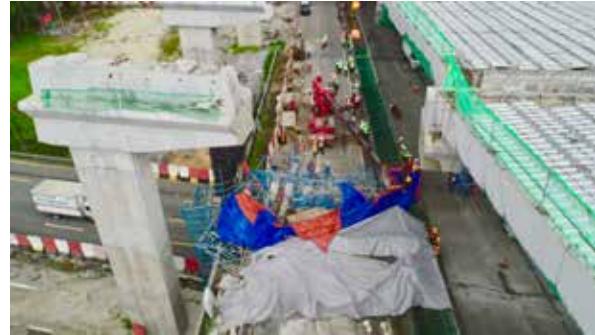


Figure 5: The Designated Person for Concreting should be trained on aspects such as design specifications, installation procedures, inspection and disassembly of formwork and falsework. He should also be aware of the risks and understand the safe work procedures that have been established by the contractor.

1. structural integrity and adequacy;
2. working at height;
3. falling objects;
4. manual handling; and
5. operational management (such as failure to inspect on regular basis, insufficient ties or braces, unauthorised changes and overloading).

Besides these, there are also site-specific hazards that the construction team should be able to identify, such as vehicular movement and sloping ground.

Contractors should appreciate that training on its own is not enough. Supervision may still be required for newly trained workers and they should be given opportunities to gain experience working in a range of conditions. When appointing foreign workers who may be skilled but who do not have any formal qualifications, contractors may need to assess them in the actual working environment. Both sections 17 and 24 of OSHA, as well as regulation 4 of BOWECS Regulations clearly outline that all parties are responsible for the safety of themselves and others who may be affected by their work activities.

Best Practice #2 - Design information and safe work procedure

The second best practice is the design information and safe work procedure. Why is design

⁴ Further information is available from <https://mbam.org.my/designated-person-training-on-concreting/>

information important? The first reason is that the PEPC who design formwork and falsework is usually less familiar with construction site activities and conditions, and most likely never visited the site before a design contract is awarded to them. The second reason is to ensure that the contractor understands and is clear about the real requirements of the falsework in its construction activities. The design information, or design brief, should be clear and available to facilitate the preparation of designs, calculations and drawings. This will also enable decisions to be made easily during subsequent phases of work. Some aspects of the design brief that need to be emphasised are:

1. the condition of the site or ground on which the formwork and falsework will be erected;
2. the availability of formwork and falsework materials and components for use; and
3. the existence of permanent structures to support eccentric loading that may be applied to formwork and falsework structures.

Apart from that, the design brief must also state the constraints and limitations that exist at the project site. This design brief should be prepared as early as possible to give the PEPC sufficient time to design, check the availability of materials, conduct a risk assessment and prepare a safe work procedure. Sufficient time



Figure 6: This design brief should be prepared as early as possible to give the PEPC sufficient time to design, check the availability of materials, conduct a risk assessment and prepare a safe method statement. Sufficient time is also important to allow the PEPC, if necessary, to revise the design.

is important to allow the PEPC, if necessary, to revise the design. On the part of the contractor, time should be given for them to review the design that has been prepared by the PEPC, especially the concept, adequacy, validity and compliance to legal requirements and good engineering practice.

Best Practice #3 - Roles and responsibilities

The third best practice is on roles and responsibilities, specifically clarity on the roles and responsibilities of the parties involved in a project, in every aspect, work and phase of the project. This division of responsibilities is very important to ascertain who is responsible for what. It is also important to ensure that the contractor has sufficient workers to comply with every legal and contractual requirement and for all parties to agree on the division of responsibilities to avoid duplication of responsibilities or unassigned responsibilities. In adhering to this agreement, the main contractor, as the entity with full control over a construction site, should manage, monitor and co-ordinate each worker at each stage of the work phase.

The main contractor should also make sure that the PEPC, DP (Concrete) and sub-contractors appointed have carried out the agreed and prescribed duties and responsibilities. The duties and responsibilities stated in a contract should not be of lesser scope or override the duties and responsibilities stated in the legislation. For example, although the duties and responsibilities for ensuring the safety of the workplace regarding formwork and falsework are borne by the contractor, the PEPC, as the designer of this structure, also has the responsibility to ensure that the design is carried out using safe engineering practices. The designer must also conduct any necessary test and inspection, and prepare the information, including risk assessment of the formwork and falsework being designed. These duties cannot be transferred to another party and the designer is accountable at all times.

Best Practice #4 - Communication and co-ordination

The fourth best practice deals with communication and co-ordination. Effective communication is essential to ensure that all necessary information, instructions, training and supervision are received



Figure 7: Effective communication is essential to ensure that all necessary information, instructions, training and supervision are obtained and understood.

and understood by each worker. Co-ordination ensures that the sequence of work is adhered to, especially if it involves structural stability. Among the lessons learned from accidents that occur in construction projects is about the interface or relationship between two organisations or workers. The contractor should establish the mode of communication between his manager and the PEPC on how information is conveyed and updated. In many instances, during an accident investigation, the contractor and PEPC produced different sets of design drawings!

Among the interfaces that need to be considered are communication between the contractor and the PEPC and communication between PEPC and DP (Concrete). For example, the contractor should ensure that the design brief supplied to the PEPC covers all important aspects. The scope of the design that does not come under the PEPC, such as the ground condition (soil condition), must be ensured by the contractor to be suitable. This is because the PEPC design usually assumes that there is no backfill at the site of the falsework structure and the surface profile is flat. Another example is that the DP (Concrete) needs to make sure he understands the design drawing supplied by the PEPC. The DP (Concrete) must understand the significance of the information, to ensure that all design conditions are met.

Best Practice #5 - Inspection and supervision

The fifth best practice is inspection and supervision. The general requirements of

BOWECS require a PEPC to certify that formwork and falsework construction are safe. To carry out this purpose, the appointed PEPC has an overall responsibility to ensure the safety of the formwork and falsework, particularly that there are no errors, omissions, misunderstandings and cost or programme pressures, which could jeopardise the safety of the formwork. The BOWECS Regulations also require DP (Concrete) to carry out supervision during installation and make thorough inspections, especially after installation is completed and during concrete pouring. Nevertheless, the overall accountability is still borne by the PEPC who certified the formwork and falsework to be structurally safe. The use of permits to load/unload can help the contractor and PEPC to ensure that work can only proceed with authorisation.



Figure 8: Proper inspection can identify defective components and formwork and falsework are used according to the design assumptions and limitations.

In addition to these legal requirements, BOWECS regulations oblige the PEPC to supervise the construction of the formwork and falsework structures he designed. He is also responsible for the stability of the structures. In this case, the design of formwork and falsework should include drawings, design details, specifications, bills of quantity and calculations. The main purpose of the formwork and falsework inspections is to ensure that the installation follows the design specifications and the structures are used within the permitted limitations and assumptions. Inspections of the formwork and falsework assemblies should include inspections of components that have normally been reused from



Figure 9: The formwork and falsework structure need to be tied and braced to accommodate lateral forces.

previous construction sites. This is to ensure that defective components are isolated and not used.

The inspection is also to ensure that the formwork-falsework is used according to the assumptions made during the design and no incidents had occurred that could affect the safety of the structure, such as being hit by a vehicle. The contractor must ensure that safe access is provided for DP (Concrete) to carry out inspection, and a proper walking platform with guard rails and toeboard is required if the risk of a worker falling is from heights of more than three metres.

Best Practice #6 - Stability and robustness

The sixth best practice is about the stability and robustness of formwork and falsework structures to accommodate lateral forces. The BOWECS Regulations require the contractor to appoint a PEPC to certify that the formwork and falsework (including re-shore) are structurally safe. Among the things that the PEPC has to pay attention to is the knowledge of the loading path acting on the components of falsework. Although most of the forces applied to the structure are vertical loads, lateral forces must also be taken into account. For this purpose, the formwork and falsework structures need to be tied and braced to accommodate lateral forces. Information regarding these ties and other supports should be detailed in the design drawings, including whether these temporary structures require support by permanent structures. The strength of the ground and floor to withstand the forces or loads that may

be applied should be ensured during the design phase. The PEPC may need to communicate with the permanent structure designer.

Apart from ensuring that the structural design has sufficient strength, the design also needs to be robust to accommodate loads resulting from unforeseen conditions, such as weather and strong winds. Loads resulting from concrete pouring activities using selected machinery should also be ascertained and taken into account during the design process. The sequence of concrete pouring should be specified, if necessary, to prevent undue loading. To this end, good engineering considerations gained through experience are essential. Specific responsibility for ensuring the stability of the formwork and falsework structure rests with the PEPC who designs this structure, while the contractor is responsible for ensuring that the PEPC carries out his duties and ensures that the entire workplace is safe.

Conclusion

The BOWECS Regulations places the overall duty of ensuring the safety of concrete work on the contractor, but the contractor must appoint a PEPC to carry out the specific duties prescribed by the regulations. *The Chief Inspector Special Order No. 1 Year 2020 on the Safety Management of Temporary Structure (Scaffolding, Formwork and Falsework)* places duty onto the manager appointed by the contractor to manage the usage of formwork and falsework during construction.

In summary, there are six good practices that need to be given special attention by contractors, managers and engineers (including PEPC) to prevent formwork and falsework collapsing during concrete work. These best practices are in relation to:

- Knowledge and experience;
- Design information and safe work procedures;
- Roles and responsibilities;
- Communication and co-ordination;
- Inspection and supervision; and
- Stability and robustness.

These best practices are derived from the essence of legal requirements and lessons learned from accident forensic studies carried out by the authors. ■