Chapter 9 Temporary demountable structures

Key points

The failure of any temporary demountable structure (TDS), no matter how small, could have devastating effects. As a result, their design, safe erection, use and deconstruction are an important part of event planning.

As an event organiser, you should ensure that the design of a structure meets the requirements of the structural concept. Ensure that the location of a structure onsite is appropriate and that there is a plan of how it will be built (and dismantled) safely.

You should ensure that:

- **you use people who are competent in temporary demountable structures at an early stage in the planning process to help you;**
- **the structure is built to the agreed design;**
- **safety-critical checkpoints in the build are identified and that checks are made by a competent person before work progresses to the next checkpoint;**
- **undertake the work safely by having competent staff and a suitable onsite operational management system in place;**
- **ensure there is a suitable maintenance and inspection regime for the completed structure, which will also require monitoring for the effects of wind and weather;**
- **allocate adequate time and resources for each of the above stages.**

243. This chapter aims to provide practical guidance to help those organising events to manage the safe erection, use and deconstruction of temporary demountable structures (TDS). It does not specify a particular way of achieving safety, but sets out a general approach.

244. While this chapter will complement the Institution of Structural Engineers' document *Temporary demountable structures: Guidance on design, procurement and use*, and other guidance such as MUTA's *Safe Use and Operation of Marquees and Temporary Structures,* it is not meant to be used instead of these more detailed documents and other relevant design standards.

What the law says

245. HSE are the health and safety enforcing authority for the erection and dismantling of temporary structures except for marquees and similar tents. Local authorities (LAs) will retain enforcement responsibility for marquees and similar tents and for the use of all completed structures during the event itself.

246. The requirements of the HSWA and the Management of Health and Safety at Work Regulations 1999 will apply to the erection, use and dismantling of TDS.

247. Depending on the type of structure, its use and the build process employed, the requirements of the following sets of regulations may apply:

- Workplace (Health, Safety and Welfare) Regulations 1992;
- Provision and Use of Work Equipment Regulations 1998;
- Lifting Operations and Lifting Equipment Regulations 1998;
- Work At Height Regulations 2005;
- Personal Protective Equipment at Work Regulations 1992;
- Control of Substances Hazardous to Health Regulations 2002;
- Manual Handling Operations Regulations 1992.

248. The erection of temporary structures at entertainment events falls within the definition of 'construction work' in regulation 2(1) of the Construction (Design and Management) Regulations 2007 (CDM). There is one exception to this, set out in paragraph 13(a) of the CDM ACOP – 'the putting up and taking down of marquees and similar tents designed to be re-erected at various locations'.

249. However, HSE policy is that the CDM Regulations do not provide a useful regulatory framework for temporary structures used in the events industry. HSE consequently focuses on compliance with the provisions of the Health and Safety at Work etc. Act 1974 and related regulations when considering temporary structures at events.

Event organisers and contractors involved with temporary structures (including marquees) will be expected to address safety in such a way that they comply with the HSWA and the regulations mentioned above.

250. For further guidance on other relevant legislation including design standards see the Institution of Structural Engineers publication: *Temporary Demountable Structures. Guidance on design, procurement and use (third edition)*, section 4 'Statutory control'.

Defining temporary demountable structures (TDS)

251. Temporary demountable structures (TDS) are designed to be rapidly erected and dismantled many times. Generally, TDS are in place for only a short time.

252. TDS are widely used for a variety of functions at events. These structures may include (but are not limited to) tents and marquees, viewing facilities (including temporary seating and viewing platforms) and stages.

Developing the design concept of the structure

TDS requirement/specifications

253. Before procuring a TDS, the event organiser should consider:

- What is it to be used for?
- What will it need to be able to do?
- Who will be using it?
- How will it be used?

254. Event organisers and those working on their behalf should identify their requirements for TDS at the planning stage. Where they may not have the necessary technical competence they should seek further advice from a competent person eg a TDS contractor/designer.

255. It is important that the organisers and contractors ensure the concept fully meets the requirements of the end user e.g. the artist and that the end user has fully understood the limits of the concept, eg location, budget and available timescales.

256. Once all relevant parties have agreed the design concept, it should be finalised. Where possible, avoid taking forward provisional or incomplete design concepts. This can result in structures which fail to meet their requirements and will inevitably require last-minute modification, which could lead to safety problems.

Comment [HaSE12]:

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An organiser decided to use a proprietary seating system, designed and engineered to be erected without alteration. However, once installed, it was apparent that the view from some of the front row seats was obstructed. A decision was made onsite to lift the stand using scaffolding. Alterations were made without design consultation. Once the concert had begun and the stand was in use, the scaffold 'unzipped' and the stand collapsed.

TDS stability

257. To ensure the stability of a structure during erection and use, consider its location and orientation early on in the planning of an event.

258. The organiser and TDS contractor should carefully consider the following factors, which may influence the choice of location for temporary structures:

- Is there enough information about the load bearing capacity of the ground or floor? Take account of previous ground disturbance, eg farmland. Geotechnical engineering assistance may be required for sophisticated structures and/or unreliable ground conditions.
- Possible effects of ground elevation and prevailing winds.

- Is there enough information about the suitability of ground conditions at any structural anchorage point? ‘Pull tests’ may be required.
- Is it an adequately drained site? Avoid locations that become unstable due to flooding as this could cause either the load bearing capacity of the ground to be reduced or washed away beneath the structural supports.
- Is the site flat or can it be made flat?
- Are there overhead power cables?
- Does the proximity of surrounding buildings, structures and vegetation create risks in relation to the possible spread of fire?
- Are there any gaps or basements under the ground/floor surface?
- Are there any restrictions on access (and use) for construction plant and equipment?
- Any other known hazards relevant to the location?

(Look at the IstructE temporary structures guidance for more detail).

259. Where there are limitations on the use of the site for TDS, organisers should provide contractors with site information as early as possible in the planning process, to allow them to fully consider its implications in the design of any structure. If necessary, allow contractors access to carry out their own site assessment where reliable information on site conditions is unavailable.

Sponsors

260. Where a structure is likely to carry advertising, then this requirement should be included in the design concept.

261. The event organiser or other nominated person should manage the production and placement of advertising to ensure that it is made of suitable material, dimensioned and placed appropriately.

262. The TDS contractor should make it clear which structures are suitable for carrying advertising and what form of advertising are permissible. Where the TDS contractor has not approved a structure for advertising, then the organiser should ensure that no advertising is attached to it.

Developing the structural design

263. The next step is to develop a design to meet the requirements of the design concept. In some cases, the TDS contractor will also

undertake this design role and, as a result, they will need to be aware of the following points.

264. The design of temporary demountable structures is outside mainstream civil and structural engineering. TDS designers should have specific knowledge and understanding of:

- the type of loads likely to be experienced by a TDS and their effects upon the TDS;
- the properties of the materials normally used in their construction;
- the properties of the proprietary systems (and their structural elements) used in their construction;
- the work techniques necessary for construction and the health and safety risks involved with these techniques.

265. The TDS designer should ensure any design:

- follows the recommendations of the Institute of Structural Engineers *Temporary Demountable Structures* Guide and any other applicable regulation/guidance, eg fire regulations;
- will maintain stability and structural integrity (including the likely effects of dynamic loading) at all times during erection, use and dismantling;
- takes workers' safety during construction and deconstruction into account;
- includes materials whose properties and performance will maintain the integrity of the structure, for example during a fire;
- has considered factors, which although not directly related to safety, could affect audience behaviour and therefore potentially have safety implications, eg audience sight lines.

266. TDS include modular systems. In the case of modular design, the process will consist of identifying and verifying the most appropriate modular configuration for the application.

267. Any novel or unusual structures should be subject to a period of testing by a competent person to ensure the design concept is adequate and that the structural calculations are accurate and concur with the physical form.

268. Where the structure is unusual, the organiser should arrange for a 'structure rehearsal' to allow tour management and crew the

opportunity to familiarise themselves with the structure and the techniques required to construct and deconstruct it in a safe manner.

269. All relevant parties should ensure that any design is realistic in terms of the timescales and budgetary resources available for implementation.

Design verification

270. The TDS contractor should ensure that a competent person verifies the final design (and any future modifications) independently.

271. The TDS designer should ensure that the design process is formally signed off and traceable including any modifications.

Planning for the safe erection and dismantling of the structure

272. It is likely that an event organiser will contract a TDS contractor to safely erect and dismantle a temporary structure. It is important that the event organiser choose a competent TDS contractor.

273. In support of this, the event organiser should ensure that their prospective contractors can:

- demonstrate knowledge and understanding of the work and the health and safety hazards involved;
- provide evidence on the competence of key staff for the project and trained workforce. Crew undertaking specialist roles such as rigging should be able to prove that they have the appropriate competencies.
- confirm they have sufficient resources to undertake the work;
- provide evidence of previous successful work, which shows they can adopt and develop safe systems of working;
- in the absence of experience of previous work, demonstrate an appropriate level of technical ability.

274. Membership of an accreditation scheme or organisation may assist in this regard.

Risk assessment

275. Ensure that whoever builds the structure (in most cases the TDS contractor) undertakes an assessment of the likely hazards and risks inherent in the techniques required for construction and deconstruction. This may require the TDS contractor to obtain

specialist assistance. Key construction and deconstruction hazards may include:

- working at height;
- transport;
- slips and trips;
- electricity and fire;
- loading and unloading operations;
- lifting operations;
- manual handling;
- use of machinery and tools.

For further detail, see ww.hse.gov.uk/construction

276. The outcome of the TDS contractor's risk assessment should serve as guidance about how to safely construct and deconstruct the structure onsite. This could be in the form of suitably clear plans and drawings that identify the sequence of safe construction (and plan for the safe dismantling of the structure).

277. A safe system of work should be established for the construction and deconstruction of the structure, eg choosing the correct way of safely working at height.

278. The TDS contractor should make erection/dismantling plans and drawings available to those managing the construction of the structure onsite and ensure those undertaking the work (supervisors and operatives) have an adequate understanding of the erection/dismantling plans and safe systems of work.

279. A programme of works, including key safety checkpoints (hold points), can help to communicate critical erection/dismantling stages to site supervisors/operatives.

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Safety checkpoints:

After constructing the foundations of a stage these should be checked by a competent person before work progresses. The next step would be to build the lattice superstructure which then needs to be checked at critical points by a competent person. The next step would be to install lighting and sound equipment all of which would require safety checks before use.

TDS build/dismantling

280. Before work starts, TDS contractors should inform the event organiser (or those delegated responsibility by the event organiser for the site, eg production manager/site manager) of any significant health and safety issues or requirements that may occur during the build, use of, and dismantling of the structure. An example of this would be the use of cranes or forklift trucks. In this way, event organisers can plan and work with their

TDS contractors to develop safe systems of working and ensure that all significant risks on the site are properly controlled.

281. Where hazards relating to stability and structural integrity are identified by a designer and cannot be fully resolved, the TDS contractor should manage those hazards in consultation with the designer. The TDS contractor should tell the event organiser about this.

282. You should work to create good co-operation and co-ordination among those involved in building and dismantling a structure. It requires effective communication at all levels, see the communications chapter for details. Plan to minimise conflict, particularly between those contractors carrying out concurrent or consecutive activities on the same structure.

Site induction and rules

283. Event organisers and their TDS contractors should make all workers aware of any site-specific risks and operational rules before starting any work, eg consider a 'site health and safety induction' for all workers who arrive onsite for the first time.

Welfare for the workforce

284. The nature of TDS construction means that it can take place almost anywhere. Like any workplace, fully consider washing/drying, toilet and eating facilities. These arrangements should be in place before work starts.

Time and resources

285. The TDS contractor should ensure that the structure can be built given the available time and resources. Where long working hours are involved, the event organiser (sometime through their site manager) should take steps to minimise any associated health and safety risks.

286. The agreed erection and dismantling plan should be flexible enough to deal with any delays, eg bad weather, without adversely effecting safety.

Monitoring and review of construction work

287. TDS contractors should ensure there are systems in place to monitor implementation of the erection and dismantling plan and intervene in the event of any deviation from the plan that puts people's safety at risk. Any system will require appropriate levels of supervision onsite. Event

organisers should ensure the TDS contractor has put these systems in place.

Safety checks (sign off/handover of the structure)

288. During erection and before use, both the event organisers and TDS contractor should be satisfied that the design specification has been followed. Complete all the necessary design and safety checks. If you don't have the necessary in-house expertise to help determine this, you may need to engage specialist structural engineering assistance (particularly for structures that are more sophisticated.

289. The TDS contractor should sign off/handover the temporary structure formally to the event organiser as safe to use.

TDS operational use onsite

290. Once the structure is erected, operational risks must be managed to ensure people's safety at all times. Consider any operational limits on the structure in the event management safety plan/s. See chapter 2 planning and managing an event for more details on safety plans.

291. The event organiser and TDS contractor should provide other contractors accessing the completed structure (for example during the 'load-in' of lights and sounds on a stage) with details of:

- any incomplete areas of the structure, eg voids or missing guardrails;
- any ongoing work on the structure;
- structural limitations (such as load bearing capacities and locations, wind loadings) in its current state;
- any other risks associated with the structure and work environment, eg lighting/electrical/fire.

Weather management:

292. Almost all TDS used outdoors are susceptible to the effects of constantly changing climatic conditions and so appropriate management systems should be in place to:

- monitor and measure the local weather conditions;
- define and deliver a plan to deal with variable loading conditions that can affect the structure and exceed the safe working parameters of the structure, eg changing ground conditions due to prolonged rain can significantly affect the resistance offered by ground anchorages. In this case, the ground conditions and anchorages may need reassessment by specialists.

293. One of the greatest hazards to structures such as marquees, big tops, stages and audiovisual support is the wind. Most TDS are designed to be safe for use up to a certain wind speed, The event organiser and contractor should be clear as to the value of this designed wind speed and the wind management plan required to ensure the TDS stability at all times.

294. Public venues using TDS should be fitted with an appropriate anemometer to allow monitoring and recording of local wind speeds. Typical wind management plans will define action levels, based on local wind speed-readings. These readings will dictate the need for modifications such as removing sheets or blow-out panels to maintain stability and minimise the risk of component failure, or when the structure and surrounding area should be evacuated.

295. The design parameters for structures on the event site may vary from type to type. The action levels should be noted and key staff aware of the procedures.

296. Other climatic conditions that can impact and therefore may require consideration when deploying or using a TDS include:

- rain and its effects on the ground and any anchorage;
- lightning and the affects of a strike on a TDS (see Electrical and lighting chapter para 546 to 550 for further details);
- snow and the impact of snow load on a TDS.

Comment [HaSE14]: Para numbers required

Modifications during use

297. Occasionally structures may need to be adapted to suit specific site conditions/layout. It is quite simple to make additions to modular systems as long as representatives of the TDS contractor/supplier carry them out. If applicable, the designer should approve the changes. To help with effective communication, it is a good idea to document these changes.

298. The event organiser/deputy should ensure that all significant modifications of the structure are referred to the TDS designer for verification and after their authorisation, signed off.

Maintenance and inspection during use

299. The event organiser should agree a suitable system of maintenance and inspection with the TDS contractor. Depending on the type of event and the time of year, it may be that a TDS contractor provide a 'standby service for structural matters onsite or just an emergency callout service.

300. For long-term projects, agree a regular maintenance and inspection programme by a competent person. Carry out additional inspections if there is a forecast of heavy rain, high winds or snow or if any unforeseen incident affects the structure.

301. A thorough check of the structure should take place following removal of any secondary fixtures (banners, lights, audio cabinets or tables, chairs and internal fit out in the case of marquees). This is to check that no components have been inadvertently damaged or removed that could affect the safe deconstruction of the structure.

TDS documentation summary

302. The event organiser should ensure the following key information and documents are available and passed on to all relevant parties:

- design concept;
- construction drawings (erection and dismantling plans);
- calculations (summary);
- risk assessments and safe work method statements (erection and dismantling plans);
- site layout plans;
- wind management plans;
- fire resistance certificates;
- contractor competency (association/accreditation certificates);
- crew training/competency certificates;
- structural completion certificates (sign off/handover certificates);
- emergency contingency plans for structures;
- lifting equipment and lifting accessory certificates of thorough examination and test.

Temporary demountable structure checklists

303. TDS checklists can help. For example, MUTA have a 'recommended minimum checklist for assembled marquees' as contained in the MUTA best practice guide. Further information can be found on the MUTA website **www.performancetextiles.org.uk.** The Institution of Structural Engineers publication *Temporary demountable structures. Guidance on*

design, procurement and use (third edition) also includes checklists for planning, construction and use of temporary demountable structures.

Case study: Video screen collapse

A video screen attached by winches to support system collapsed into an events area. The video screen had been erected to show a major televised sporting event. Fortunately, there were no injuries as a result of the collapse. The incident occurred in the afternoon before the event was due to be broadcast that evening. The expected public attendance was about 2500 and around 55 people were expected to be working back-stage and in event control. Had this failure occurred during the broadcast, there could therefore have been multiple fatalities.

The investigation's findings

The investigation revealed that the collapse was due to an inadequate structural design. This resulted in the overloading (due to foreseeable wind forces), and inevitable failure of welds, which induced progressive failure through load redistribution within the modular supporting structure. The contractor had failed to co-ordinate their design team, which had been undertaken by multiple design parties and a final effective design had not been produced before the structure had been erected and handed over to the client.

The client, contractor and subcontractors had all failed to some extent in controlling the risks to the public and workforce during this event in:

- planning the event:
- designing the structure;
- installing the structure;
- operating the structure.

As a result of this incident:

- The contractor has developed a system of formal design and operational checking by independent competent parties.

- The event organiser has formed a checklist system which allows the contractor to formalise and demonstrate their duties from design to dismantling the structure.

Case study: Saddleback tent collapse at a music festival

A main stage, saddle-span structure collapsed at a music festival. As a result, three members of the public, who were on the stage, were injured.

The investigation findings:

- The collapse of the saddle-span structure was the result of stabilising ground anchorages failing during prevailing weather conditions.
- The saddle-span design was robust but required installation in strict accordance with their instructions. This design relied heavily upon effective ground anchorage systems and correct vertical alignment.
- The planning team decision to locate and orientate the structure into the prevailing wind direction had been flawed and had, unnecessarily, increased risks of high wind forces on the structure.
- The contractor? had not ensured that there had been effective, or independent, checks undertaken of the completed structure.
- The event organiser? had not installed effective ground anchorage systems.

- The event organiser? had not ensured that adequate prevailing soils information had been available, or interpreted, to allow an effective ground anchorage system to be developed.
- The event safety management plan was incomplete, without essential structural and ground engineering input relating to the saddle-span structure and an operational wind management plan.
- The organiser failed to operate an effective evacuation procedure as the weather continually deteriorated throughout the day.

Following this incident:

- The organiser has now:
  - employed geotechnical engineers to assist with the conceptual and detailed planning of the event;
  - commissioned structural engineers to assist with the design and operational independent checking;
  - formed systems to evaluate potential contractors more effectively.
- The local authority will commission external assistance in evaluating event proposals and will develop more stringent checking systems.