SUPPLY CHAIN SAFETY
LEADERSHIP GROUP

Highways Safety Hub

Raising the Bar 26

Safety by Design

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Contents

Objective

Safety by Design must become business as usual within all of our design teams.

This Raising the Bar Guidance Document provides practical guidance on how to the comply with the Supply Chain Safety Leadership Council Common Intent Document on Safety by Design as well as providing guidance to the Designer and Contractor as to the standardised method of compliance preferred by National Highways in securing safety by design. The Common Intent document contains 5 key themes which are replicated in this document:

- **We will expect a Safety by Design mindset from the outset**
- **We will capture and share information throughout the project life-cycle as per PAS1192:6**,
- **Offsite manufacture and assembly will be promoted as the default construction assumption.**
- **Where we can't eliminate risks, we will aim to reduce them or ultimately isolate them.**
- **We will foster virtual rehearsal as 'business as usual', with the ensuing insights informing our design development.**

The purpose of this document is to drive improvement to ensure effective whole life design for safety makes a significant contribution to eliminating or reducing harm as a consequence of the project. It does this by:-

- Capturing best practice for identifying, assessing and mitigating risks that can result in injury during the life of a project, from across the design supply chain and the wider construction industry.
- Presenting this best practice as the standard to aspire to when working on schemes on the strategic road network or other areas of the National Highways estate.
- Recognising the importance of human centric design, the key to a successful outcome

These boxes are used to highlight specific examples and links to good practice.

Scope

This safety by design guidance is applicable on all National Highways projects. The guidance is relevant to all design activities over the whole life cycle of the works and should therefore be considered from the concept stage onwards. It is intended to cover new projects or schemes and any maintenance and operational construction activities on the network.

The document applies to all designers, both in the supply chain and within National Highways, working on the development of works for the strategic road network or other areas of the National Highways estate.

Safety by Design considers the impact of the proposed work on all populations who might be affected by it throughout the lifecycle of the asset. (see GG 104 - Requirements for Safety Risk Assessment for definition of populations to be considered).

When considering the scope of design and designers, the Construction (Design and Management) Regulations 2015 Regulation 2 should be referred to for definitions of design, designer and construction work.

This document should be read in conjunction with GD 304 - Designing Health and Safety into Maintenance

The safety imperative behind Home Safe and Well also relates to Health and wellbeing. This document should therefore be read in conjunction with the Health by Design Raising the Bar document.

Due to the broad range of this scope, it is recognised that all elements will not be practical in all circumstances. However, the guidance below sets out

the levels which should be aspired to and adopted wherever reasonably practicable to do so. If it is not practical to follow the guidance and requirements within this document, an exceptions record should be kept on file setting out which aspects cannot be adopted and why. This may be applied at a programme or framework level if appropriate.

Background

Designers have a legal duty set out in the Construction (Design and Management) Regulations 2015 to eliminate or mitigate **foreseeable** risks to the health or safety of any person affected by their design, where mitigate includes the steps reduce or control and provide information. Designers have a responsibility to apply the principles of prevention to eliminate firstly, or reduce secondly, the hazards identified in each and every part of the projects' life cycle.

Beyond this legal duty, designers are morally, professionally and financially obliged to produce safe designs. In order to support Home Safe and Well, safety by design must be adopted from the outset, as decisions made early on can have a significant impact on the level of safety risk involved in construction, operation, use, maintenance and decommissioning.

Hazards are more efficiently removed early in the development of projects. Making changes during detailed design or even on site to address hazards consumes substantially more resources than addressing the issue during concept or preliminary design. The most effective way of managing health and safety risks is to design hazards out at source before relying on other control mechanisms on site.

There are often multiple designers involved in projects from concept and option studies through to preliminary and final design stages. Ensuring focus on hazard elimination at all of these phases is critical, together with effective handover between designers and provision of hazard and risk information to all stakeholders.

This document introduces two new aspects to drive improvement in how Safety by Design is delivered. The Safety by Design plan and the role of Safety by Design lead.

The Safety by Design Plan is a pre-construction phase equivalent of the principal contractor's Construction Phase. It sets out how the principal designer is going to manage and monitor the pre-construction phase and co-ordinate matters relating to health and safety during the pre-construction phase. Planning this activity is a legal requirement under the Construction (Design and Management) Regulations 2015. Existing project management plans and associated documents are expected to already fulfil the many of the requirements which may enable a new plan to be predominantly a sign posting document. However, by bringing all the requirements together in one place, it facilitates the necessary briefing to the design team and raises the focus given to Safety by Design.

The Safety by Design lead is a named individual with responsibility for ensuring designers undertake effective hazard identification, elimination and mitigation. This is not a role that takes on duties from the designers. It is a role to provide the design team with support, specialist H&S input when necessary and assurance that effective safety by design is being undertaken. This is expected to be someone already within the delivery team. The creation of this role is also intended to raise the profile and importance of Safety by Design as a business as usual activity.

Governance Requirements

There is a clear expectation within the Supply Chain Safety Leadership Group Common Intent Document on Safety by Design that arrangements for designing out hazards should be put in place from the outset of the works. These processes will be overseen by the principal designer, whether this role is fulfilled by the client during the early stages of design, a designer appointed by the client or handed over to a contractor during the latter stages of a project.

A formal handover must be undertaken where the principal designer duty transfers from one party to another. The incumbent principal designer shall provide sufficient evidence to the incoming principal designer to satisfy them that the legal duties and the requirements of appropriate additional guidance, including this Raising the Bar document, have been met. Any related outstanding areas of concern during handover shall be raised with the client.

Minimum Requirements

The following elements are mandatory requirements and suppliers shall ensure these elements are applied fully on National Highways sites. Further details on these elements are provided within this Raising the Bar document. ›

Mandatory Elements

- Designers must demonstrate consideration of safety as an influence on the design from the outset of a scheme.
- The client must ensure a Safety by Design plan is prepared containing details of how design risk management activities will be undertaken and managed during the design of the works.
- Records must be kept of the design risk management process and decisions taken which impact upon the safety of any of the populations identified in GG104 during the whole life of the asset.
- A formal handover must be undertaken where the principal designer duty transfers from one party to another.

Guidance

Overview

The following guidance is written with the expectation that it represents best practice and as such should normally be followed unless a better local solution has been devised to meet the overall objective.

1. Safety by Design mindset from the outset

A Safety by Design plan must be produced at the outset of the project and owned by the client. This plan will create a focal point to develop a safety by Design mindset. In addition to identifying the pre-construction information being provided by the client to the design team, it should set out how hazards will be identified and managed during the pre-construction phase of the works. When work is transferred between designers at various gateways, the plan for managing hazards will be included in handover documentation passed to the incoming designer.

Further reviews and updates to the plan shall be undertaken at appropriate intervals during the design of the works.

The minimum requirements for this plan are provided in Appendix 1 and an example drafted by National Highways in Appendix 2.

A key role in this plan should be that of a Safety by Design lead to provide both support to the project team, especially the designer team and undertake assurance activities to drive the delivery of safer designs. This should be an individual with a good knowledge of the requirements of the Construction (Design and Management) Regulations 2015 regulations and other relevant safety legislation and engineering knowledge related to the works to be constructed. They should have sufficient seniority within the team to be able to influence design decisions and when necessary advise the client of any safety concerns regarding the design.

To develop the team mindset necessary to eliminate risks from the outset, the Safety by Design plan shall be briefed directly to all team members as part of their induction to the project.

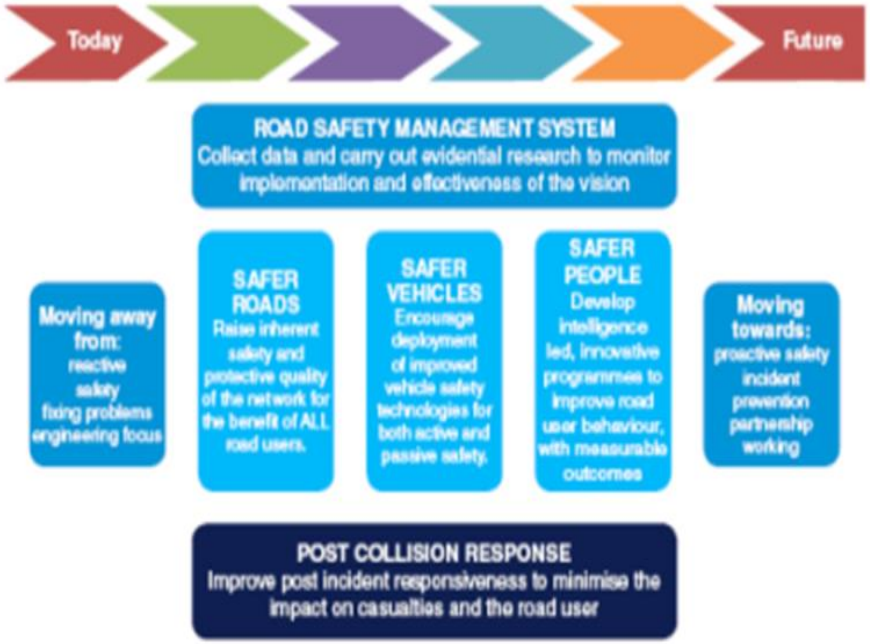
> Skanska employ "developing safety culture sessions" to raise awareness amongst their designers of the importance of design risk management decisions enabling challenge around acceptable residual risks resulting in a safety first approach to design.

Safer Systems / Human Factors

Good design must consider where, how and why people may make mistakes, in order to design to prevent these opportunities for error and manage them when they occur. Whilst a design might comply with standards, it may still not be intuitive to users; there are locations with high collision rates that are DMRB compliant but still clearly present difficulties for users. Designs which rely upon safe systems of work being followed by individuals as the primary mitigation of a hazard should be the exception not the norm.

Operational safety specialists, with extensive experience of human factors, can help to identify the potential for human error allowing it to be eliminated or managed. Assets which are easily understood by users are safer and result in a more positive experience for the user (customer satisfaction).

Designers should recognize the relationship between their designs and human factors. BIM visualization tools are likely to be of assistance in identifying possible problems prior to construction.



Human Factor considerations:

- Identify and address root cause of hazards – there are reasons why people do what they do – if you wish to change that behaviour you need to understand the WHY.
- Training – to minimise error ensure everyone has received the training they require to undertake their role
- Guidance – any guidance or policies in place ensure they are clear, concise and have been successfully communicated to all workforce. Also ensure the location of these documents are known and the protocol to suggest and inform changes is clear.
- Compliance – ensure monitoring is undertaken to ensure compliance with guidance and policies. For high levels of compliance there must be visibility of accountability and consequences if compliance is not achieved.
- Environment – Consider the environmental factor influences on your work force, this could be extreme weather conditions with the need for appropriate work wear or noise levels, temperatures. The changes in the environment can have significant effect on the human's ability to function. For example, heat can cause tiredness whilst noise or extreme weather can cause distraction or lead to safety measures not be undertaken.
- Governance and communication– Ensure workforce know who to contact for assistance, how to make contact and where to seek additional support. Any changes must be clearly communicated to all.
- Empowerment – the workforce is one large team from the design concept stage to construction and delivery. Ensure everyone involved feels empowered to deliver the design safely. The workforce needs to feel recognised and listened too, they need to feel part of the process to ensure they feel comfortable and competent in their role which will result in a high level of commitment, responsibility and pride in the work they deliver. The workforce needs to have the confidence to raise issues of concern and feel supported by the governance structure.

Safety by Design Workshops

A workshop should be a proactive environment in which to examine issues and challenge accepted practice with an intent to develop solutions. Topics could be identified as part of project reviews, through challenges raised by members of the delivery team or via lessons learnt from other projects. Safety by Design workshops should be organised at a frequency appropriate to the complexity or scale of the project. These workshops should be used to develop the safety by design mindset within the whole of the delivery team.

There is no one size fits all template for these workshops. The requirements for individual projects should be developed as part of the Safety by Design plan. The key is to ensure the right people are present

and sufficient time is allowed for ideas and issues to be fully explored. Workshop planning should consider the following:

The WSP M62 J20-25 Smart Motorway team held a Safety by Design workshop focused on the major causes of worker injuries on the highway network. Designers were challenged to identify means of eliminating some of the major causes of slips, trips and falls during construction, operation and maintenance.

- Stage of project
- Focus areas under consideration
- Appointment of key stakeholders (e.g. is contractor known)
- Complexity
- Duration

The workshops should include representation appropriate to the stage in the design development and scale of the works, but consideration should be given inviting representatives from:

Early engagement with stakeholders via Safety by Design workshops should be the default position. Designers should provide sufficient early information to stakeholders to allow them to determine if they wish to be involved at a particular stage. On schemes which may impact on the communications network, early involvement is vital with National Roads Telecommunications Service (NRTS). Being the backbone to the functionality of the network, late involvement may delay works or incur extra risks, costs and the potential need to re-plan. These additional pressures introduce an avoidable increase in safety concerns.

- Client
- Designers
- Contractors
- Maintainers
- Operators
- Traffic Officer Service
- External stakeholders - such as Network Rail where design may affect their assets and

Note: Maintainers and operators need to consider all those undertaking specialised work on the network alongside the major contractors. E.g. NRTS and associated technology contractors.

As well as specialists in key areas including:

- Health and Safety
- Occupational hygienists
- Human factors
- Temporary Traffic management

The workshops can look at whole scheme issues or be focused on specific geographic, technical or operational aspects of the works.

The following safety topics and challenges could be considered at these workshops:-

› Buildability
› Maintainability
› Deconstruction / Decommissioning
› Impacts on different populations (GG104)
› Whole life costing
› Challenge the norm
› Human factors
› Clash detection
› Design standards
› Materials
› Key risk elimination
› Design coordination

(Workshop could consider associated health issues at the same time.)

2. Digitally Capturing and Sharing Information

Building Information Modelling (BIM)

BIM has the potential to be a valuable tool in identifying, co-ordinating, managing and communicating risks and facilitating clash detection throughout the project lifecycle. The application of BIM supported by 3D modelling will not be appropriate for all works. When BIM is adopted for the works, it should be used to capture and share health and safety information applying PAS1192 / 6 or ISO 19650-5 where appropriate and using structured common data environments and data sets.

BIM also has an important role to play in managing change which is often the time hazards are unintentionally introduced. The modelling should be linked to the design change register to allow effective review of changes for any consequential clashes or conflicts.

3D and 4D Design and Modelling

Digital design should be the default position adopted to aid the management of hazards. Designers should maximise the use of digital technology and project portals giving access to single source information to work collaboratively, share information and manage hazards. The degree of adoption will be proportionate to the benefits which are significantly affected by the nature of the project.

> The Smart Motorway Programme Alliance have adopted ProjectWise as a means of sharing and controlling project information, and the Revizto tool for collaborating within the 3D model environment. Both these can allow multiple people to access and exchange information at the same time.

Project Information Models (PIM) should capture existing hazards and form a fundamental part of the pre-construction information. The PIM model should be a live entity which grows with the design, is accessible to all members of the project delivery team and key stakeholders, is handed over to the site delivery team, kept up to date and captures asset data and residual hazard information on handover. Use of the models promotes elimination of errors at all stages of the project.

Hazards recorded in the model and associated with visible warning symbols, should be those which are particularly significant. Designers should avoid excessive numbers of warnings on works information drawings and in BIM models relating to generic risks, which may result in the significant ones being missed.

The model should be used in discussion with the contractors to identify opportunities to pre-fabricate or pre-assemble some systems off-site and for consulting maintainers and operators on the impact of the solutions.

Future BIM integrated projects should utilise BIM to develop integrated programmes for construction operation and maintenance which will further highlight areas where risks accumulate.

3. Design for Manufacture and Assembly (DfMA)

Off-site manufacture and on site assembly supported by Design for Manufacture and Assembly (DfMA) should be the default position. DfMA focuses on ease of manufacture and efficiency of assembly by simplifying the design of a product. Allowing more work to be undertaken in controlled conditions away from the roadside drives quality, efficiency and predictability whilst substantially reducing the fatal risk of working next to live traffic.

DfMA does not have to be complicated to be effective. The first stage of the Smart Motorway Programme Alliance's programme of retrofitting stopped vehicle detection units to the network considered opportunities for standardisation and off site production. A single solution for a pre-cast concrete base, manufactured off site, was developed through collaboration between the technology designers, structural engineers, socket manufacturer, the supply chain and the onsite assembly partner. This eliminated a number of hazards, reduced time on site and the number of visits required to complete installation.

The main benefits of DfMA are:

- **Worker Safety -** less man hours at the side of the road, by removing construction activities from the side of the road and placing them in a controlled factory environment there is the likelihood of a significant positive impact on safety and quality.
- **Speed -** One of the primary advantages of DfMA in construction is the significantly reduced programme on-site using prefabricated elements. This not only benefits the road user from short road works durations, the dangers of incomplete or temporary works but also the road worker whose exposure to working next to live traffic is greatly reduced due to shorter assembly time.
- **Higher quality, lower cost and sustainable** - A highly automated approach can enhance quality and efficiency at each stage. There may be less waste generation in the construction phase, greater efficiency in site logistics, and a reduction in vehicle movements transporting materials to site. By using fewer parts, decreasing the amount of labour required, and reducing the number of unique parts, DfMA can also significantly lower the cost of assembly. It can often make demolition/re-use/recycling more straight-forward

A case study of DfMA being applied on a National Highways Project. https://www.ice.org.uk/knowledge-and-resources/case-studies/dfma-a453-road-widening-new-approach-bridge. This case study describes how the use of modular and offsite manufacturing solutions helped save 6 months construction time and reduce site labour by 30% on the A453 Road Widening project

Designers should record an assessment of opportunities for DfMA as part of the design process. This could include challenging conventional issues, such as standards, materials, sources, leading to creating more opportunities for offsite production and on-site assembly. Assessments should include input from appropriate representatives from the supply chain to ensure the reviewing team have the necessary skills, knowledge and experience to undertake an informed assessment.

Balfour Beatty have standardised the use of the (BB) King sheet pile retaining wall system which allows construction of retaining walls with up to 40% less steel for walls up to 4m retained height and significantly faster to install. It is now the standard retaining wall design providing a King post wall type solution in one material - steel sheet piles which are constructed offsite to length and then installed/assembled on site. Eliminates use of insitu FRC works as makes a SSP solution work in many varying ground conditions.

When reviewing opportunities for DfMA, it is recommended that the key components which make up the infrastructure being installed as part of

the works are identified and recorded. Each element should then be challenged to determine if elements of in-situ construction can be undertaken off-site and ready made products delivered ready for assembly on site.

Whilst offsite manufacture and assembly will minimise some risks, the additional risk of transportation needs to be considered. Designers should ensure they plan for transportation requirements as part of the DfMA process and accordance with Raising the Bar 36 – Lost Loads. With DfMA, as with any other lean approaches, ensure the simplification of the process has been clearly communicated to all involved. Ensure any use of technology has been thoroughly explored such as reliability and resilience.

On the A14 scheme provision of a standard cast in-situ bridge deck was challenged due to the amount of work at height required and the umber of crane lifts involved. The proposed new solution involved prefabricating the deck off site at a precast yard in the section of the A14 scheme where the viaduct is located, then transporting and lifting it into place as panels. This reduces the number of journeys required to deliver materials to the site as a large amount of prefabricated material can be delivered in one go and therefore has a positive impact on local communities and eases congestion and traffic management in the area.

A benefit of a precast yard means that slabs are constructed under controlled conditions which improves safety as well as mitigating risks associated with weather.

4. Design Risk Management

Design risk management should not be undertaken solely within discipline focused silos.

Design risk management is not defined in terms of a single process or a one off activity. It is not necessary when identifying hazards to establish mitigations at the same time as this may require additional data to be collected or other designs to progress before the full picture can be assessed. Hazards and mitigations should be reviewed, and details added as the design progresses and more information becomes available. To be effective however, there are key aspects which must be considered in developing the appropriate safety by design approach for the design of any particular works package.

- Complexity of works
- Any unusual aspects
- Constraints which may affect construction
- Issues which may not be obvious to a competent contractor
- Innovations

Appendix 3 includes an example from the supply chain of an approach to ensure the right checks are applied to deliver effective design risk management.

A designer inadvertently combined multiple hazards relating to work on a parapet over a live railway line. The designer recorded a single hazard of working at height. This does not differentiate between the risk of workers falling from height and the risk of workers dropping tools on passing trains. The mitigation for these two risks is likely to be very different but recording and monitoring them is difficult if they are combined as a single entry.

From the Outset

Design risk management must be undertaken through the whole life of the design. The elimination of hazards is more effectively done at the outset as it avoids having to revisit decisions later in the design or having to develop mitigations whilst already constrained by earlier decisions. In this respect the client brief can have a significant impact and those writing these should have an awareness of the potential to introduce constraints which may have an unintentional adverse safety impact.

The specifications and standards form the foundations of designs and therefore can have a significant role to play in the management of hazards. Authors of specifications and design standards should be able to demonstrate that during the development of the documents, they have discharged their designer duties and provided information on residual risks to the health and safety of any person

Whilst document authors may not be in a position to eliminate or mitigate potential hazards which will be affected by site specific circumstances, they should consider and provide information in relation to potential hazards arising from the application of the particular specification or standard. This can take the form of a hazard log included as an appendix to the specification or standard which conveys useful and relevant hazard information to those applying the standard.

Authors of specifications and standards should consider how a number of these documents may be applied together to create a final product.

GD 301 – Smart Motorways and GD 300 - Requirements for new and upgraded all-purpose trunk roads (expressways) – development of both these standards included development of a schedule identifying potential hazards when applying the standard in site specific circumstances.

Hazard Identification

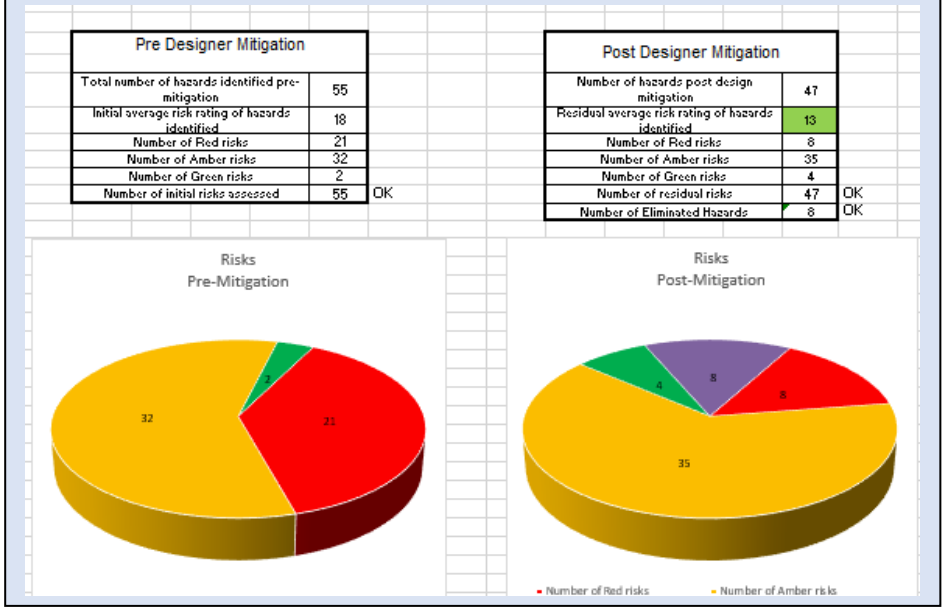
Designers must accurately identify hazards and avoid the use of generic lists of hazards. Designers should avoid combining multiple hazards as a way of simplifying the design risk management schedule. It is possible that

a hazard in one location may require a different mitigation to the same hazard in a different location in the works.

Designers must consider all foreseeable risks, including those which might be considered normal or generic e.g. working from height and seek to reduce these. However, for the purposes of communicating hazard information to the principal contractor, they should focus on the unusual, not obvious, difficult to manage, or where critical design assumptions apply.

When identifying hazards, designers should consider the root cause of that hazard. The first requirement of the principles of prevention is to avoid risks and to do this, designers need to consider the root cause not just the potential consequence. Failure to identify the root cause will likely result in a less effective or appropriate mitigation. Tools such a 5 Whys can be used to identify root causes.

Allocating numeric values to hazards is not essential. Assessing likelihood and severity factors does provide an opportunity to prioritise design mitigation resources. Also, before and after mitigation scoring supports reporting and graphical representation of the effectiveness of the design risk management applied to the project.



Design teams should consider hazards as multidisciplinary issues. Hazards need to be recorded and be accessible to and understood by the whole team using a design risk management schedule stored within a Project portal such as ProjectWise.

Paragraph 3.2 of GG 104 sets out the key factors to be considered when identifying a hazard. The description of hazards within a schedule should reflect this list.

Hazard Mitigation

The use of separate mitigation entries under eliminate, reduce and inform headings is one way of demonstrating the application of the basic hierarchy of the principles of prevention.

Mitigations need to be proportionate to the risk identified. However, where a mitigation is not considered applicable on this basis, the decision should be recorded along with whatever evidence is available to substantiate that decision.

When considering mitigations, it is easy to make assumptions about what is / isn't possible based on historic approaches. It is important that assumptions are challenged, and historic approaches tested if improved whole life safety and the Zero Harm goal is to be achieved.

When determining a preferred mitigation between a range of potential approaches each one shall be assessed using whole life costs and benefits into account in accordance with GD 304 - Designing Health and Safety into Maintenance.

Alternative design solutions shall also be compared using GG 104 so as to allowed safety to be appropriately considered alongside other factors which may determine the preferred option.

The design risk management schedule can be used to capture any factual information about a hazard which may be useful to others who have to manage the risk later in the project. It could include links to documents which contain the information and instructions to secure the health and safety of the worker for the lifecycle.

A copy may be made available to the principal contractor to maintain during the construction phase and provide the updated version to the principal designer for incorporation into the health and safety file. The principal designer should review the live version during construction and liaise with the principal contractor over any issues arising.

Hazard Information

The design risk management schedule should include information relating to any residual risks which have not been eliminated through the design process. This information must be factual, relevant to the hazard which remains and assist those who may have to manage the residual hazard, be they other designers or contractors on site.

Information relating to residual hazards should be linked to hazard annotations included on drawings or within 3D models. However, the designer must liaise with the contractor to agree the form for the presentation of hazard information, ensuring it is accessible to the people on the ground.

Design Reviews

All design reviews should include consideration of hazards and the evaluation of safety risks as an agenda item. Assumptions and decision logs should also be reviewed to identify potential safety implications.

Attendance at design reviews should generally be from organisations which represent the whole lifecycle of the asset being constructed, as listed under Safety by Design workshops.

Any critical designs need to be subject to a periodic review, unless it is agreed with the principal designer that the amount of design activity does not warrant this frequency i.e. during a 'design freeze'.

The client shall ensure that such reviews shall be chaired by a person with sufficient training, skills and experience, and for the purposes of consistency, generally by the same person throughout the life of design.

Within the Designer's project documentation, the competency requirements of the chairperson shall be defined, agreed with the client and evidence that these requirements have been met shall be recorded and maintained.

External peer design reviews, with a specific focus on safety risk management can be adopted with the frequency based on the levels of risks involved.

Buildability should feature within Design reviews. It may also be appropriate to hold separate buildability reviews for specific unusual or particularly difficult aspects of the design.

Temporary works requirements must be considered within Design reviews and where appropriate due to scale or complexity, subject to specific buildability reviews.

A record shall be maintained of design reviews and this shall include:

- Titles, organisation and role of all attendees
- Date, time and location of the review
- Details of the documents, drawings, specifications, calculations or other aspect of design being reviewed

- The design risk register including the addition of new risks, mitigations and further design actions required
- Actions arising from the review meeting
- The signature of the lead design coordinator, that the record is a true reflection of the meeting.

Records and Assurance

Records must be kept of the design risk management process and decisions taken which impact upon the safety of any of the populations identified in GG 104 during the whole life of the asset. The potential mechanisms for meeting this requirement include:

- Safety by Design Plan
- Design strategy record (This should broadly follow the requirements set out in GD301 - Smart motorways.)
- Design Issues record
- Design change record
- Design Risk Management Schedule
- Design decision log.
- Assumptions Log
- Information Provided Register

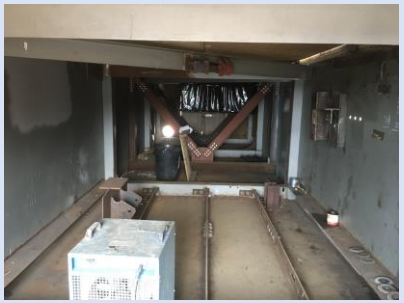
These mechanisms could be used to record design decisions arising from design reviews, safety by design workshops and inter disciplinary design co-ordination meetings, decision owners and any potential impacts on safety taken into consideration in making the decision.

The Safety by Design lead should review design risk management records to confirm they demonstrably show:-

- Designers are proactively identifying hazards and updating records;
- Actions required are being completed and records kept
- Mitigations have achieved a reduction of risk to as low as is reasonably practicable;
- Mitigations are practical and that the measures identified are within the remit of the designers to deliver;
- Mitigations have been completed;
- Measures contained within Table E of the Nationally Applicable Annex to GD 304 have been adopted where relevant;
- Information on residual risks is useful, relevant, proportionate and has been effectively communicated.
- Risk has not disproportionately been transferred from one population to another. (HSE approved concept of trade off may be applied Ref: HSE Doc. R2P2 Reducing Risk and protecting people)

The outcome of the review should be reported to the principal designer and the client.

At Gade Valley bridge strengthening, a full size mock up of the part of the bridge was created. This was so techniques for the installation of strengthening plates within the box girders, which are a confined space, could be trialled.



5. Designing Collaboratively

Designers must work collaboratively with constructors, maintainers, operators and customers in order to better inform design models for both permanent and temporary works solutions. The process for delivering this collaboration should be set out in the Safety by Design plan.

Reviews of hazards and mitigations should be undertaken via inter-disciplinary design co-ordination meetings at a frequency proportionate to scale of the works and levels of risk.

On projects with 3D /4D models in place, virtual rehearsals will be adopted as a primary means of collaboration when considering the means of assembly and buildability. Full scale mock ups should also be considered as an effective means of testing assembly or construction assumptions.

> The design of new brackets to fix stopped vehicle detection radar units to existing gantries evolved through several iterations. Once a final design was agreed, the assumptions on how it could be installed were tested on a full size mockup to ensure the method was fit for purpose prior to its roll out at hundreds of locations across the network.

Designers should be an integrated part of the construction team; on hand to collaboratively resolve any design issues / changes that arise and record

> See Appendix 4 for examples relating to digital rehearsals.

design change in a collaborative way. Where changes impact on the design risk management schedule, the schedule must be updated and the safety implications of the change recorded via the appropriate technical query or request for information process. Hazards associated with design changes during construction, should be captured at regular ongoing joint meetings and where necessary added to the Design Risk Management Schedule which should be maintained and updated during construction in prep for handover.

Designers should refer to industry best practice to identify developments which represent opportunities for improving the safety of designs. When identified, these should be used to review and update Table E of GD 304 - Designing Health and Safety into Maintenance where appropriate.

Virtual Rehearsals

Using 3D+/4D-enabled design models will enable the construction team to undertake a virtual rehearsal of how a product is to be constructed in order to ensure the proposed methodology will work. For example the constructor will be able to virtually check that the size of plant needed to construct the product will fit and be able to operate safely within the area before any commitment needs to be made.

The use of 3D visualisation allows all stakeholders to understand how the design and construction will impact them. 3D modelling of both temporary and permanent works enables simulated construction, operation or maintenance in order to reduce uncertainty, improve safety, resolve issues, and simulate and analyse potential impacts.

Temporary Works

Many of the problems caused by Constructability of Temporary Works are due to lack of focus and planning at an early enough stage in the project therefore it is good practice not to leave temporary works design until construction stage, the key point being that the later Temporary Works are considered, the more difficult and costlier it is to make any necessary adjustments to the design, leading to a likelihood of imported risk. Where DfMa is a feature, designing standardised temporary works for each manufactured element can provide an easy and safe front end solution. An early understanding of Temporary Works requirements and staging is essential to understand the true scope of works and the associated risks.

To achieve this the early involvement of designers with Temporary Works and Constructability competencies should be sought. Where a contractor is not yet appointed in the early design phase of a scheme, the use of Early Contractor Involvement (ECI) should be adopted to test Constructability as it may also reduce or eliminate the need for Temporary Works in the first place.

It is recommended that designers provide a Pre-Construction Temporary Works Schedule at the earliest possible stage and share this with the contractor. All parties can then review and comment to gather the broadest possible views on Temporary Works and Constructability. This should not be confused with the Temporary Works Register which is intended to feed from the Pre-Construction Temporary Works Schedule in readiness for the Construction Phase.

It is considered good practice for the NH Project Manager to work with the principal designer, principal contractor temporary works co-ordinator and designers to enable the Temporary Works Register to be combined with the projects Permanent Works Register. This will help enable a consideration of integration between Permanent Works Designs and Temporary Works Designs as the designs are developed. Great care and engineering attention to planning is needed during design, with close on-site supervision & planning in the execution of temporary works schemes, to ensure safety.

People Requirements

Training and Competency Requirements

Competence requirements shall be determined in accordance with GG102 - Quality management systems for highway works

Each organisation shall annually assess every individual's SKE needed to undertake their allocated roles and where identified record any agreed remediation plan. An individual assessment shall be in place within one month of joining an organisation and as part of the process when being allocated a new role.

The assessment is recommended to include a description of the qualities assessed and allocate a competence assessment grading. The qualities are suggested to include:

- Skills in design risk management
- Knowledge in duties of designer and principles of prevention
- Knowledge of documents on Highways Safety Hub
- Experience in application of above.

The assessment is recommended to include a description of the qualities assessed and allocate a competence assessment grading.

> Principal designer team from both designer and contractor have to complete CDM training course and then each individual on the principal designer team has to undertake a Competency Assessment, which is reviewed and approved by Head of Design and each team member is formally appointed - BAMNuttall

Responsibilities of Personnel

Responsibilities of key personnel, the client, the designers and the principal designer shall be as set out in the Construction (Design and Management) Regulations 2015.

Continuous Improvement

Incident Investigation

To drive continuous improvement and development of early project hazard elimination, designers and principal designer lead representatives should be involved in on site incident investigations to determine if the design could have been prevented. Engagement with the contractor during the construction preparation stage should be used to facilitate communications regarding incidents on site to enable designers to attend investigations.

Designers should be engaged in regular workplace inspections of site during construction. This should be included within designers personal development plans to further their understanding of construction

Lessons Learnt

Lessons learnt reviews should not be restricted to the start and end of the design phase. Designers should maintain a live lessons learnt log, which on major projects should comply with the PCF product Lessons Learnt Log.

Lesson learnt records should be briefed out to team members during progress meetings and shared with the wider community at regular intervals through the appropriate forums.

Sharing can be achieve using the Highways Safety Hub website (Highwayssafetyhub.com) and the principal designers working group (https://www.highwayssafetyhub.com/principal-designers-working-group.html)

Sharing, as well as viewing previous lessons learnt from a range of major projects, can also be done via the MP knowledge management SharePoint site https://highways.sharepoint.com/sites/MPKnowledgeManagement/SitePages/Lessons-Learned-Reports.aspx.

Contractors should provide feedback to designers on hazard mitigations in order to support improvement in the elimination and mitigation of hazards during the pre-construction phase. Where formal reviews do not take place, the principal contractor should provide feedback to the principal designer, on hazards which have been identified on site and which should be considered when designing future works.

References / Useful Contacts

The following documents and websites provide additional information for designers when considering safety in design including guidance from other industries which may be applicable to highways work.

Construction (Design and Management) Regulations 2015

L153 - Managing health and safety in construction

GG102 - Quality management systems for highway works

GG 104 - Requirements for Safety Risk Assessment

GG 128 - Requirements for reporting incidents, events and undesirable circumstances: health, safety, wellbeing, structural and environmental

GD 304 - Designing Health and Safety into Maintenance

Supply-chain-safety-leadership-group

Common Intent Documents
- Safety by Design
- Utility Strike Avoidance
- Lost Loads

Raising the bar guidance documents
Principal designers working group

Office of Rail and Road - Positive and negative indicators of H&S by design

Healthy by design – A guide for Crossrail design teams

https://www.twforum.org.uk/home

• Specification for collaborative sharing and use of structured H&S information using BIM: PAS-1192-6

The Construction Playbook

Appendix 1 –Safety by Design plan guidance - requirements

The plan should consider as a minimum (sign posting to other documents where information already exists will be appropriate):-

- Arrangements for managing and monitoring the pre-construction phase and co-ordinating matters relating to health and safety
- Competence (Skills, knowledge and experience) required within the Team including plans for on-going training and development
- Approach to embed a safety culture within the design team
- CDM dutyholders and contact details
- Roles and responsibilities for design risk management,
- General whole life management approach to design risk management
- Use of technology to track, log and monitor progress with elimination or mitigation of hazards
- Ownership of cross discipline hazards – e.g. Services, contaminated land
- External stakeholders / consultees
- Frequency and format of addressing safety aspects within design reviews,
- Recording actions taken in accordance with the principles of prevention.
- Process for capturing temporary works requirements
- Arrangements for communicating changes to the design team
- Arrangements for communicating latest safety alerts and similar with the design team
- Arrangements for Provision of Information to others

Appendix 2 –Safety by Design plan - example

The draft below is an example from National Highways of what a Pre-construction phase plan or a Safety by Design plan might look like.

Pre-Construction Health and Safety Plan Requirements

The Pre-Construction Health and Safety Plan shall, as a minimum, contain the following information:

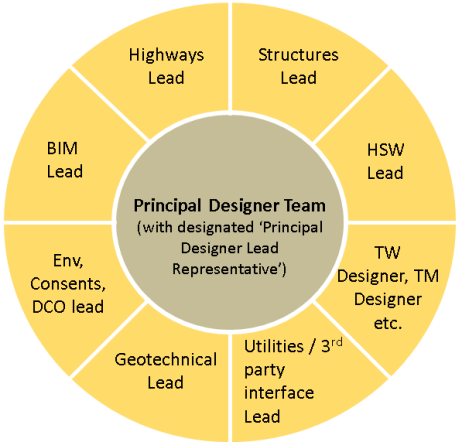
a) An overview of the Project and timescales aligned to the Client Brief

b) Define the organisational arrangements including organisation chart; which will detail the make-up of the team which will discharge and assure the requirements of the Principal Designer role including the key positions of Principal Designer Lead Representative (PDLR), the discipline leads and the Health and Safety lead.

NB. The CVs and/or capability assessments of these named individuals can be requested by National Highways at any time

PDLR will be the most senior person leading the Design/Development phase from the supplier organisation and will able to demonstrate clear understanding for the duties of the Principal Designer role will be discharged by the organisation.

An example graphic to demonstrate component parts of the Principal Designer team for a project is:



This is not ubiquitous, the wheel and roles will vary dependent on the scale, scope, risk factors, specific interfaces etc. of the project or scheme

c) Provide an overview of how the Principal Designer will plan, manage and monitor the pre-construction phase and coordinate matters relating to health and safety during the pre-construction phase, particularly when design, technical and organisational aspects are being decided

Expectation is that this focus specifically on the individual elements:

i) Planning
ii) Management
iii) Monitoring

and the key requirements, mechanisms, interventions etc. which will be implemented and assured to deliver optimum H&S outcomes during the design, construction of the project/scheme and ultimately the operation and maintenance of the completed asset/s.

d) Detail the key processes and mechanisms which will: Identify and eliminate or control, so far as is reasonably practicable and provide information to others. Estimate the period of time required to complete work or work stages and ensure all designers comply with their duties.

e) For the following list of Key Deliverables; define:

i) the approach,
ii) roles and responsibilities,
iii) how they will be evidenced,
iv) how staged assurance will be provided to the Client Rep throughout the design phase including submissions at design freeze/hold points and SGARs (Stage Gate Assurance Reviews)

<u>Key Deliverables</u>

- Pre-Construction Information sufficiently developed for the stage of design
- Health and Safety file information developed for the stage of design
- Progressive integration of Health & Safety information into agreed Building Information Modelling (BIM) Requirements
- Application of hierarchy of controls to safety and Occupational Health risks highlighted during the design phase

- Consultation, coordination and cooperation with HE Operations regarding the design for maintenance and operation within the scheme [signed acceptance from stakeholders where this has been defined as a requirement by the Client Rep]
- Consultation, coordination and cooperation with other key project stakeholders [signed acceptance from stakeholders where this has been defined as a requirement by the Client Rep]
- Departures from design standards, outlining how they will be sought, appropriately risked assessed and consulted with all relevant stakeholders.

Appendix 3 – Safe By Design Procedure – Supply Chain Example

Throughout the design process and specifically in design risk assessments, design development, technical reviews and certainly prior to issue of deliverables, the following "10 question test" should be applied to the design to help identify hazards throughout the asset lifecycle and address them with the hierarchical approach of eliminate, reduce and control:

1. Do I know how it will/can be assembled, operated, used and maintained and is it satisfactory?
2. How will it behave during construction, operation, use and maintenance?
3. What impact does the construction sequence have on my design?
4. Have I assumed a construction method in my design?
5. What plant would be needed for construction and maintenance and how do materials get to site and into the works?
6. Is anything in my design very sensitive to construction tolerances?
7. Have my important assumptions been communicated?
8. What might go wrong and how could I de-risk it? Has fire safety been considered?
9. Is there a simpler way to do this?
10. What does the Project Technical Reviewer think?

If any of these questions:

- have not been explored
- identify ignorance of an issue
- identify there is no clear owner of a risk or,
- result in identifying important assumptions that have not been communicated to those who need to know

Then appropriate action must be taken to address the questions prior to finalising the design.

This is likely to involve one or more of the following:

- Closer engagement with the Contractor to agree construction methods, resolve issues of buildability, complexity and risk ownership.
- Closer engagement with the Client, to discuss the residual risk and offer safer alternatives
- Escalation within the team to someone able to advise with sufficient authority
- Consultation with a relevant Professional Head of Discipline or Technical Authority

Appendix 4 – Examples of best practice relating to digital rehearsal

Do it Better

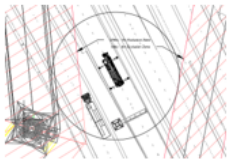
Better Practice & Continual Improvement Capture

CMWM Template
December 2020
Page 1 of 1

Title: 4D Sequencing of Gantry Installation & Overhead Interface | **CI Ref:**

Standard Method

- *Develop written lift plan*
- *Develop 2D drawing detailing exclusion zones around overhead cables including crane position and lifting radius*
- *Identify maximum lifting radius at jib height based on crane supplier's duty charts*
- *Manually transpose this information onto 2D drawing and identify clashes*



Improvement Summary

Fit (what we did):
Firstly we obtained models of the pylons from NPG, and by modelling the sag/swing of the lower cables, and in line with GS6 we were able to model the exclusion zones for both overheads in 3D using AutoCAD.
This was then imported, along with the scheme's BIM model, crane and a low-loader, into Synchro.
The lift plan was then transposed into a programme written within Synchro, and by using 3D paths, rotations etc we were able to link the model to the relative tasks in the programme and fully animate the sequence of works exactly how they would occur on site.

Function (how we know it works):
By modelling this precisely in AutoCAD, we know the exclusion zones are exact, and by calculating where the crane would need to sit in order to safely work outside of the exclusion zones, we can efficiently demonstrate we can carry out the works in a safe manner.

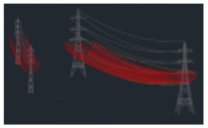
Value (how we maximise value):
The output from Synchro provides us with a video that anyone can play on their computer and can be communicated to anyone involved in the works, or to anyone who needs assurance that the work can be done safely.

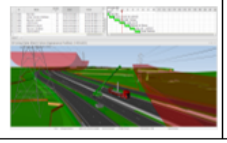
Key Drivers for Improvement

	+	Neutral	-
Safe Operations	✓		
Health & Wellbeing	✓		
Sustainable Operations		✓	
Efficient Delivery	✓		
Cost Effectiveness	✓		
Customer Service	✓		
Brand Impact	✓		

Innovative Method

- Obtain 3D models of Pylons from NPG
- Model sag/swing of cables
- Model exclusion zone in accordance to GS6
- Obtain 3D model of crane
- Produce 4D sequencing of works in Synchro
- Export video with multiple viewing angles & present to workforce as a visual method statement





Benefits Realised

- Innovative & engaging way to communicate method of work
- Assurance to Stakeholder NPG that operation will not impact on OHL (GS6 compliance)
- Highways England & Costain confident workforce will not be put at undue risk
- Mitigate on-site issues with positioning of crane – all calculated within CAD (operation carried out during road closure – time is crucial)
- Allows optimisation of crane size, thus providing a cost benefit

Additional Information

Contact Details	Ben Thompson ben.thompson@costain.com
Date Raised	07/05/2021
Supply Chain Involved	Costain Donval Engineering Northern Powergrid

LEAN	Which of the 8 Wastes has been reduced?	Transport	Inventory/ Materials	Motion	Waiting	Over Production	Over Processing	Reduced Transportation	Defects	Skills
				✓	✓		✓			

https://www.highwayssafetyhub.com/uploads/5/1/2/9/51294565/digital_rehearsal_____right_first_time.mp4