



VISION ZERO
SAFE & WELL EVERY DAY

'The FATAL 6'

1

Contact with moving machinery and isolation

2

Workplace transport and pedestrian interface

3

Work at height

4

Workplace Respirable Crystalline Silica

5

Struck by moving or falling object

6

Road Traffic Accidents

Mitigating high consequence hazards

Code of Practice for:
Safe Stressing of Prestressed Concrete Products

2023 Edition 2

Preface

This Code of Practice brings together the many developments, not only in health and safety legislation, but also in good practice within the prestressing industry. It gives a guide to the current good practice but, in an ever-changing situation, can only be totally up-to-date at the time of its publication.

MPA Precast is committed to achieving a high standard and universal approach to Health and Safety, and part of this is the provision to employees, customers and designers alike of clearly presented information about the systems of work employed.

This Code has been prepared with the assistance of the membership of MPA Precast and support from the Health and Safety Executive (HSE), who have provided assistance with its development; this is much appreciated.

This edition will be published primarily as a download from the Safequarry website, although printed copies will be made available to members, training organisations and the Health and Safety Executive. This document will be updated online – you should check to ensure that you are using the latest version.

Stressing of prestressed concrete is acknowledged to be a potentially high-risk activity, as it involves the use of industrial prestressing equipment that uses hydraulic rams to stretch high-yield wires and strands with forces that can be more than 1500 tonnes.

This Code of Practice has been produced for the following purposes:

- To communicate good practice management of health and safety to produce prestressed concrete products.
- Raising safety awareness within the industry.
- Planning the production process and equipment required.
- Training of all personnel involved with stressing operations.
- Preparation of risk assessments and safe working method statements.
- Generation of safe systems of work for maintenance and safe interventions.

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Every effort has been made to ensure that the statements made and advice given provide a safe and accurate guide; however, no liability or responsibility of any kind (including liability for negligence) can be accepted in this respect by the publishers or the authors.

Foreword

HSE have provided a limited amount of support in the development of this guidance.

HSE encourages and welcomes industry codes of practice such as this produced by MPA Precast, which receive careful consideration and input from key players within the industry who have the health, safety and welfare of those involved in prestressing work foremost in their mind.

If a stressing bed system were to fail, serious injuries or fatalities are a possibility. If the work is planned in line with this code of practice guidelines, and carried out by competent operatives, using equipment properly maintained and inspected then many accidents can be prevented.

I am pleased to acknowledge the work of the MPA Precast and those involved in preparing this code of practice. It brings together good practice within the industry and has the interest of those involved in the manufacture of prestressed concrete products at heart. It is only by the industry showing leadership, working in partnership, and taking ownership of the management of risk that improvements will be made, and I commend its use to all concerned.

Health and Safety Executive

This is the second edition of the Code of Practice for the Safe Stressing of Prestressed Concrete Products. Its revision and update is another step towards Vision Zero in the precast industry and accords with the aims of raising standards for health and safety in the workplace.

The dangers of the prestressing process should be fully appreciated, and this code goes a long way towards establishing a safer working environment for all involved in prestressing operations. We therefore advise all manufacturers involved in prestressing operations to take a detailed review of this code and implement all necessary health and safety policies, procedures and physical controls recorded.

'Struck by flying or falling objects,' is one of 'The Fatal 6'; the high consequence hazards that have been responsible for the majority of serious and fatal injuries in the mineral products sector. Prestressing operations present a very significant risk of 'Struck by' injuries if they are not well managed and controlled. This Code goes a long way towards helping to establish a safer working environment for all involved in prestressing operations.

We therefore recommend that all manufacturers involved in prestressing operations perform a detailed review of their prestressing operations and taking into account the content of this Code, implement improvements to their relevant health and safety policies, procedures and physical controls, where required.

**Message from MPA
CEO – Jon Prichard**

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The members of MPA Precast and stakeholders have made this publication possible. Whilst many individuals have contributed, the following are amongst those who deserve particular mention:

- | | | | |
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0.1 Definitions

Most of the terms used in this document are in common use. However, the following definitions are intended to remove any ambiguity:

Abutment: Fabricated steel assembly at the end of a stressing bed sometimes drilled with holes to suit the wire/strand pattern, which takes the forces from the stressed wire/strand and transfers them into the ground, concrete or steel frame of the mould.

Anchor: See barrel, wedge and button heading.

Appointed Person: The person employed by the 'company' to have overall control of the stressing operation and to act on behalf of the 'company'. The Appointed Person must have adequate training and experience to ensure the implementation of a safe system of work.

Approved Training Provider: Training delivered to PS1-PS4 (see Section 1.5), which is quality controlled under the Proskills Global/MPA Precast Training Partner scheme

Barrel: This holds the gripping wedge at the end of the stressing beds. Sometimes referred to as a collar, cone, or chuck.

Bed Operative: Person directly involved with the preparation, set up, tensioning and de-tensioning, or casting and clearance of product on a casting bed.

Button Heading: Term used to identify an anchor system for wire where the wire is deformed by force to create a rounded end.

Calibration Unit: Laboratory calibrated and certificated load cell and read-out used to calibrate the pump and jack system on site.

Calibration Certificate: The certificate supplied with details of the jack/pump load/pressure rate.

Certificated: Having been trained and qualified to fulfil a particular role and holding a valid licence/certificate of training, gained by attending a recognised course of instruction for the task in question.

Company: The manufacturer of precast concrete components and associated items and services.

Competent Person: The person is regarded as competent if they have 'sufficient training and experience or knowledge and other qualities to properly assist the employer to meet his health and safety obligations.'

Components: Any member, article, or item comprised of precast concrete or ancillary metalwork.

Dead End: The fixed end of the bed opposite to the end used for stressing the wire/strand.

Design Engineer: Professionally qualified person ultimately responsible for the overall design of stressed products and stressing operations.

Designer: The person or persons who produces specifications, estimates, drawings, details, designs or calculations for a particular contract.

Dispenser: For dispensing wire or strand from coil – also known as lobster pot, pod.

Extension: Distance identified by the engineer that a wire/strand has to be pulled to achieve the design load.

Ferrule: Thick washer used to spread the load when using button heading.

Flooring: The precast concrete components that form the structural element of a floor and may include associated precast components.

Grip: See barrel and wedge.

Hazardous Area: The area identified as a dangerous area in the vicinity of the bed stressing operations.

Hollowcore: Precast concrete flooring system, which for the purposes of this Code is deemed to include terms such as 'wideslab', 'solid planks' etc.

Live End: The end of the bed at which the wires/strands are stressed.

Manager: The person in charge of the prestressing team, undertaking the work for the company.

Multi-Stressing: A system to tension multiple wires/strands at the same time by moving the end abutment.

Operatives: All other site personnel involved with the prestressing works.

Piab System: As an alternative to hydraulic tension, this system uses a crane to pull the wire/strand and a load cell called a Piab trips the crane at the correct load.

Precast Company: The precast company engaged in the supply and/or manufacture of precast components.

Precast Designer: The designer of the precast components, working for or on behalf of the company.

Prestressing: The process of inputting stress into a concrete element before ("pre") the concrete is stressed in its service role.

Pretensioning: The process of prestressing in which the wire or strand is tensioned before ("pre") the concrete is cast.

Strand Pattern: Correct position identified by the design engineer for the wire/strand to ensure that the performance of the slab is achieved normally with the minimum amount of strand and concrete.

Stressing Jack: Sometimes referred to as a stressing gun, this is the unit that tensions the prestressing wire/strand individually. Various designs are available and compatibility between the equipment is imperative.

Stressing Operative: Person directly involved in the preparation, set up, tensioning or de-tensioning of stressing operations.

T Beams: A flooring system that uses prestressed inverted precast concrete T beams together with block infills.

Tendon: This is a term that commonly refers to both wire and strand.

Tendon Design Load: Load identified by the design engineer to which the wire/strand should be stressed.

UTS: Ultimate Tensile Strength (often referred to as the Breaking Load) of the wire/strand.

Work Area: The area on a site where precast components are manufactured and prestressed.

Work at Height: Work where there is a significant risk of injury to persons due to falling.

Working Drawings: The layout drawings, section and details, produced by the precast designer and issued for client approval and production purposes.

Wedge: This grips the prestressing wire/strand in conjunction with the barrel, sometimes referred to as a bullet or carrot.

Please note that where the term 'he' or 'his' is used this should also be taken to include 'she' or 'her' as appropriate.

0.1

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His Majesty's Government

- Health and Safety at Work etc. Act 1974
- The Management of Health and Safety at Work Regulations 1999
- The Work at Height Regulations 2005
- The Health and Safety (First Aid) Regulations 1981
- The Control of Noise at Work Regulations 2005
- The Electricity at Work Regulations 1989
- The Personal Protective Equipment at Work Regulations 2002
- The Provision and Use of Work Equipment Regulations 1998
- The Lifting Operations and Lifting Equipment Regulations 1998
- The Manual Handling Operations Regulations 1992
- The Control of Substances Hazardous to Health Regulations 2002
- The Construction (Design and Management) Regulations 2015
- The Construction (Design and Management) Regulations (Northern Ireland) 2016
- The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013
- The Control of Vibration at Work Regulations 2005

Health and Safety Executive

- HSG 246 Safety in the storage and handling of steel and other metal stock
- Health surveillance for those exposed to respirable crystalline silica (RCS) – Supplementary guidance for occupational health professionals (amended January 2016)

British Standards Institution

British Standards and other guidance notes are issued on a continuing basis and users of this Code of Practice should acquaint themselves with the latest updates and revisions.

- BS 5896 High tensile steel wire and strand for the prestressing of concrete –Specification

This list is not exhaustive but provides a helpful pointer to useful publications.

Note: Please ensure that you refer to the latest edition of these references.

1 The management of health & safety within the prestressing industry

This Code of Practice has not been established to describe a detailed process which needs to be followed and incorporated into specific company systems and procedures for the management of stressing operations. This Code's guidance relates to good practice principles to help ensure that, if followed, systems and procedures are in place to deliver healthy and safe stressing operations for all involved.

All the stages of systems and procedures development should involve stressing operatives, general staff, supervisors and managers together with maintenance teams. Stressing operatives must ensure that systems and procedures are achievable, with significant findings from risk assessments being well understood by the stressing operatives. Plans for further risk reduction measures should be identified where necessary. All the persons involved need to be suitably experienced and competent for the stressing element being reviewed, including a person with a level of understanding of H&S legislation (for example a minimum of IOSH Managing Safety, Level 3 NVQ/SVQ or Level 5 RQF). Competence and experience are also required for the safe use of equipment associated with the stressing operation, e.g., the use of cranes and lifting accessories, whilst it is not covered by this Code, should be given equal consideration and managed safely.

The following stages need to be included in the local health and safety management process, particularly all stressing operations and the principles described for all general health and safety management requirements.

1.1 Stressing Policy

The policy needs to clearly describe the strong commitment and direction required for all stressing operations by the most senior person within the organisation. The policy must commit to ensure that all relevant elements of this Code are implemented and should identify an improvement plan process where required, ideally through the risk assessment process (see Section 1.3).

The policy will outline the need to reference and use this Code during pre-job assessments, monitoring and reviews, especially the development and review of risk assessments, which will clearly identify current arrangements and improvements to be progressed. The risk assessment process is the key to the management of health and safety arrangements during the stressing process. The policy will detail the importance placed on the risk assessment process for stressing operations and general health and safety management, and that assessment compliance will be monitored at management meetings, especially the monitoring of improvements recorded on the assessments.

An example of a stressing policy can be seen in Appendix 1. It is not expected that this example is copied and used as is. All points stated on the example should be reviewed and altered to suit the organisation's current stressing management practices, including planning for improvements, which should be progressed in a prioritised manner, all overseen and monitored by the policy signatory and senior management.

The policy will be reviewed on a maximum twelve-monthly basis in line with the guidelines detailed in Section 1.8.

To support the policy's accuracy and development for local stressing operations attendance at industry meetings is expected, together with a commitment to communicate any incident details and actions taken to improve standards. This approach should help all industry members raise safety standards.

1.2 Code of Practice

This Code needs to be used as an integral part of the development of good practice for safe stressing operations. It has been developed to provide a stage by stage guide for the practices which need to be included within risk assessment, safe systems and training etc.. This will help to ensure that stressing is completed in a safe and controlled manner and that consideration is given to the design, selection, use and maintenance of safe plant and equipment across all industry organisations. The Code needs to be used/referenced during all stages of stressing operation management, particularly during risk assessment reviews, where the specific section for the stressing stage being reviewed is referenced by all involved to ensure that the Code's standards are implemented or planned in the near future.

The Code should be a working document and should form a key part of the risk assessment process. It should be actively used and referenced by all staff during stressing operation reviews etc.. It is expected that the section being reviewed will be referenced on the risk assessment/safe procedures to help formally record its use and link from industry standards to on-site practices.

1.3 Risk Assessment

An effective and thorough risk assessment process should involve all relevant staff and contractors. Risk assessment development can take some time to develop accurate risk assessments, which record current arrangements and plans for improvement. The time and effort taken will ensure that the developed risk assessment becomes an integral element of the organisation's health and safety management process - the 'cornerstone' for health and safety management.

The format to record the assessment is not important. Scoring/levels of risk must never be used as a factor when deciding if the correct level of safety has been achieved. One should focus on the hazards identified and ensure that the risk assessment team confirms that all existing controls are recorded. If the controls are not in place, then they need to be added to the improvement section. All improvements listed must detail who is responsible and by when they are to be progressed/completed. Confirmation of the existing controls and improvements must be decided by using the experience of the risk assessment team and referencing relevant documentation, especially this Code. The team's involvement is more important than a risk rating score. One should not get drawn into thinking that a low score/green colour means high/good practice standards.

The risk assessment process should seek to identify all reasonably practicable improvements. An example risk assessment form is contained within Appendix 3 together with instructions for its use.

Risk assessments should be reviewed annually or more frequently if there has been an accident, incident, near miss, change in personnel, introduction of new machinery/process, etc.. The review process should not be rushed; it should be completed over a period of time, i.e., a few days depending on availability of key staff.

Risk assessments need to be formally confirmed by all persons involved. Where the need for improved control measures is identified there should be a formal management process for agreeing time scales and monitoring implementation. As improvements are completed the assessment will need to be updated to reflect the improvements made.

The monitoring process should be included in team meetings and at senior management meetings on a weekly/monthly basis, as appropriate and in line with local meeting arrangements. Stressing operatives must be involved. Senior managers can offer support ensuring that target dates are not missed and that congratulations are communicated for the completion of improvements, which have raised safety standards.

1.4 Safe Systems of Work / Safe Operating Procedures (Safe Systems)

Where required from the risk assessment process, a detailed safe system needs to be produced to clearly show the stages and key safety elements to be followed for the stressing operations together with other stages as required, i.e., wire management, wiring up the beds, de-stressing, barrel and wedge cleaning and inspection, maintenance activities and undertaking interventions, e.g., dealing with wire breaks, etc.. The initial safe systems should be produced by physically watching the process, making notes and all persons confirming the safe process to be followed (including improvements if identified from the current process and requirements listed in the Code).

All relevant staff should be involved in the design and review of safe systems of work. When completed, all staff who complete and manage the systems requirements will need to formally record acceptance and understanding. Before the safe system is signed off, it is expected that the process will be performed by following the safe system exactly as it is recorded, in order to ensure that the safe system is correct. This process will be followed over time during Planned versus Actual monitoring as detailed in section 1.7. It is also good practice for a senior manager to endorse the system's requirements to add their commitment to the process being followed. If any areas cannot be completed, then the task should be stopped until full compliance is achieved. This requirement needs to be recorded on each safe system to support compliance at all levels of the organisation with the systems stages and requirements.

During the safe systems development, it is good practice to add pictures of key stages to help show the exact requirements. Safe systems should contain a balance of pictures and words. Another inclusion could be the addition of a flow chart which clearly details the stages to be followed, who completes each section and a picture of the standards to be followed.

Examples of safe systems can be found in Appendix 4.

1.5 Training and Education

Introduction

MPA Precast is committed to ensuring that all operatives involved in stressing activities carried out by its member companies are competent. This includes ensuring a good understanding of the objectives of this Code of Practice for the safe stressing of precast concrete components. The company should assess the level of training an individual has achieved and should provide training, instruction and refresher training as required.

Four modules have been designed to develop the skills and knowledge required to undertake the various tasks linked to the production of prestressed concrete products.

- PS1 – Basic Health and Safety/General Stressing Awareness.
- PS2 – Stressing Process - Storage, Preparation, Stressing/De-Stress, Product Removal.
- PS3 – Maintenance of Stressing Equipment.
- PS4 – Management of Health and Safety During the Prestressing of Precast Concrete.

Details of the content of the prestressing units can be found in the specification for prestressing training available on request from Proskills Global and MPA Precast.

Scope

The training applies to precast designers, managers, supervisors, foremen and operatives. 'General Awareness' training is also relevant to all personnel who may be exposed at some time to a prestressing environment.

Operatives who are directly involved in the prestressing production process shall be trained and certificated for unit PS1 and PS2.

Maintenance staff who support the inspection and completion of works to ensure that stressing equipment is safe and operating to the manufacturer's design requirements shall complete PS3.

Unit PS4 has specifically been developed for all designers, managers, supervisors and foremen to give them awareness of the operations carried out and their responsibilities for the process. It is recommended that all line management directly involved in the production process hold a valid PS4 certificate.

Employees who are not directly involved in the production process can be trained and certificated in unit PS1 - general awareness to give them an understanding of the operations that are carried out on site.

As part of all training modules a formal review of local safe systems of work (SSOWs) and related procedures will be completed to support their suitability, accuracy and full implementation.

Responsibility

It is the responsibility of the company employing the individual(s) and sub-contractors to ensure that they have the appropriate experience and training in the stressing of precast concrete products for them to carry out the tasks allocated to them, and for ensuring that full records of any training provided are kept securely.

Training

Procedure for the delivery of training of prestressing personnel.

Training regime for stressing operatives*



*Experienced operatives will start at Step 3 of this process then continue as stated.

The delivery of the prestressing course must be carried out by Approved Training Providers. On-site assessment of trained personnel should be carried out by suitably competent individuals with experience in the prestressing industry.

Note: The need for re-training must be regularly monitored. As per the system shown above, any employees who do not pass the yearly assessments must be re-trained to a fully competent level and re-assessed as such. Training should be carried out either internally or externally depending on the needs of the individual. Training is the responsibility of the company.

Work activities log

The company and the employee are responsible for maintaining a log of the rota, duties, SSOW reviews and hours in Step 4. This could be achieved via a logbook filled in by the employee or evidence kept by the company HR department.

Annual refreshers

Annual refresher assessments of competence will be carried out by occupationally competent individuals from the company. These could be supervisors or other line managers with a minimum of five years' experience in the industry. It is recommended that the refreshers follow the format below:

1. Observation of the employee carrying out their daily duties.
2. Discussion with the employee of the reasons for the operation being carried out as it is and how this impacts the health and safety of the operatives on site.
3. Review of local SSOWs and related procedures during assessment, confirming that they are suitable and fully implemented.
4. Recording of the observation and discussion results and feedback on further training if required.*

*The form to record the annual assessment is located in the specific Proskills Global training specification documentation.

Certification of Operatives

Certificates of training achievement will be issued to operatives who have complied with the training criteria and achieved the necessary standards that will qualify them for such a certificate. The certificate will be valid for five years, provided that the annual assessments are completed, after which a refresher practical and theoretical test will be undertaken to enable a renewal of the certificate.

If annual assessments are not completed, then the certificate is only valid for three years.

Additional categories can be added to the skills certificate after additional training has been completed satisfactorily.

Renewals of the certificates will be subjected to a period of grace of one calendar month from the expiry date. Certificates not renewed within this time frame will be deemed to have lapsed.

1.6 Pre-Job Assessments / Inspections

To support the completion of the safety controls developed during the risk assessment and safe systems process, pre-start checklists and inspections need to be completed daily. These should cover the key safety elements and requirements prior to stressing. The importance of these checks should be conveyed to all those involved in the process as this is the final chance to confirm all high priority safety elements are in place. If any item is not fully implemented, the stressing operations should not progress until full compliance with all safe systems is achieved.

There are specific/local elements which need to be confirmed as being in place in addition to the industry items listed within this Code. These must be agreed, with all persons included in the process, and recorded on a simple check sheet or incorporated into other inspection requirements to avoid increasing the number of documents completed.

Examples of pre-start/stressing inspections are contained within Appendix 2.

1.7 Monitoring, Review, Audit, Inspection & Refreshers

All business systems need to be monitored and inspected as part of a rounded and well supported management system. H&S management is no different, with the stressing operations taking priority over less hazardous activities. To clearly show/clarify all the monitoring and review elements linked to stressing operations, a scheme of inspections for the operations should be developed.

This scheme will list all the inspections completed for the stressing operation, why they are completed, the frequency of completion, when last completed, what format is used, who completes/closes out actions arising from an inspection and where records are maintained.

Some inspection elements will be completed internally and others by an external person with the required expertise for the given inspection requirement. Internal inspections need to involve all relevant persons ranging from senior managers, stressing operatives, health and safety representatives, supervisors, foremen and health and safety professionals, etc.. All elements will be recorded using specific formats suited to the requirements of the scheme item.

These can be incorporated into other forms to reduce the number of documents in place. Ideally, they should be countersigned by a senior person acknowledging the inspections' findings and actions to be progressed.

Some of the scheme items are statutory and completed to a fixed format, whilst others are flexible to meet specific site requirements and processes, and some are linked to monitor performance with a process or activity. These need to be developed to suit the stressing activities. One process used is a review of safe systems known as Planned 'V' Actual, which involves a detailed look at a safe system during the activity it controls to ensure that the written system mirrors the activities being completed.

Planned 'V' Actual reviews benefit from a rota being developed to monitor their completion ensuring all persons involved in the process are included on a regular basis for higher risk activities.

The refresher process for safe systems of work should ideally be planned throughout the year. This will help to ensure that there is sufficient focus on individual systems together with the correct level of importance being assigned to each safe system of work. The Planned 'V' Actual process can be a substitute for annual reviews.

Examples of inspection formats, etc. are contained within Appendix 2.

Each factory will be externally audited to assess the level of compliance with the Code of Practice requirements

An audit programme/protocol has been developed in conjunction with this Code to ensure that the safe working systems are being adopted and continue to be adhered to. The main topics covered by a factory audit for safe stressing will include:

- Pre-site tour audit covering site documentation and maintenance of stressing equipment
- The management of health and safety process for all stressing operations
- Stressing process and equipment
- Wires and strand
- Wiring up the bed
- Barrels and wedges
- Stressing the beds
- Guards and warnings
- Concrete casting
- De-stressing
- Removing barrels and wedges
- Training, certification, competence and ongoing assessments

It is expected that the audit report, and any action items recorded are discussed, agreed, and monitored through to completion at the respective company's Senior Management Meeting platform, to support the senior management team overseeing, and ensuring full compliance with this CoP requirements.

The audit results will be included on industry performance tables and monitored at industry meetings to support compliance with the Code's requirements.

1.8 Consultation and Communication

A positive health and safety management process requires consultation with relevant persons. Sufficient time should be allowed to ensure that consultation can take place. This process may take time. However, the benefits from discussing activities with those completing the task, agreements of task expectations, identification of poor practices and improvements, will help to raise overall safety performance and commitment to follow safe systems, etc..

The consultation process extends to, but is not exclusive to, Planned 'V' Actual audits, H&S committee meetings, team meetings, daily pre-start meetings, management meetings, behaviour-based safety initiatives (visible leadership tours), third party and factory audits, etc.. Where a formal agenda is used for the items listed, stressing operations, maintenance and inspection results, and trends need to be specific elements.

Outputs of inspections and visits need to be discussed together with reviewing the completion of improvements generated during the risk assessment process.

1.9 Accident, Incident Reporting and Hazard Alert / Near Miss

Accident, incidents and dangerous occurrences are all instances where safety has gone wrong. Thorough investigation needs to be completed with all relevant persons, especially the injured person, with actions to improve/prevent reoccurrence taken and formally closed out at safety meetings across the organisation. Details of the incident, improvements made and opportunities to learn must be communicated to help prevent similar incidents within the organisation and across the industry.

As part of the investigation linked to the stressing process, e.g., following a failure, slippage, etc., all relevant persons (operatives, supervision/management, H&S professional, supplier representative, etc.) must be involved to ensure that the root cause for the incident is established. Any equipment/evidence must be retained to support the investigation. Investigation outcomes, which could have a wider industry implication, should be communicated to both the MPA Precast H&S Steering Group and the MPA Precast Management Committee to ensure that improvements can be made across the industry where required.

Hazard alert/near miss reports give an organisation the opportunity to thank the person reporting the incident for helping to prevent an accident happening to one of their colleagues, and implement change/improvement to prevent a situation where an accident could occur. A positive hazard alert process can have many benefits to an organisation's safety and overall performance (Good Safety is Good Business style approach), especially when all levels of the organisation actively support the process.

It is expected that all organisations will operate a hazard alert/near miss process, which is visual and encouraged. Monitored numbers, categories of reports and closure of actions will be monitored at all levels of the business. Training plans need to include hazard alert reporting with all staff completing the session at regular intervals.

- Senior staff monitoring and supporting the completion of daily formal pre-start and casting checklists, together with the Code's minimum standards.
- Safety tours to monitor specific high-risk operations.
- Reviews of risk assessments for hazards with high-risk potential with operatives and key employee safety staff.
- Visible leadership tours/interaction with all levels of operational staff.
- Visual task sheets, which develop systems with pictures of the required standards.
- Planned 'V' Actual audit process, detailed above.

1.10 Behavioural Safety

Any process which fully engages all levels of an organisation in a positive manner can be classed as a behavioural based initiative, supporting the development of a positive culture towards workplace health and safety. Compliance with the involvement and communication detailed within this section would support improvement in safety appreciation and understanding.

It is important to keep refreshing health and safety aspects. This can be achieved by having several live initiatives, which are regularly repeated and linked to good practices, and then to use other processes and initiatives to promote further review of performance.

One must never forget to enforce the standards in the systems and procedures developed during the stages listed above. One must have a firm but fair response to safety violations and never walk past poor/unsafe practices. It must be remembered that we get the standards we accept, and our behaviour sets the standard. This approach will help develop a stronger safety culture and should never be avoided.

Examples of behaviour based/good and proactive health and safety initiatives include:

- Developing priority health and safety topics/key minimum health and safety standards, etc. and promoting these across all operations with all persons involved, i.e., instruction, training, improvement planning and monitoring to ensure compliance with the agreed health and safety standards.
- Establishing a set of company-wide health and safety rules alongside various initiatives and ensuring that the rules are communicated, monitored and complied with by all employees, contractors and third parties.

1.11 Good Practice Documentation

Examples of good practice documentation, as outlined in Section 1.7 above, are included in this Code of Practice. The examples are intended to give a guide to the level of detail needed to support compliance with this Code's requirements and the strong H&S standards needed during the management and maintenance of stressing operations.

The documentation covers the following areas:

- Stressing policy - Appendix 1
- Pre-start/stressing equipment inspections – Appendix 2
- Risk assessment - Appendix 3
- Safe systems - Appendix 4

2 Introduction to prestressing in a factory environment

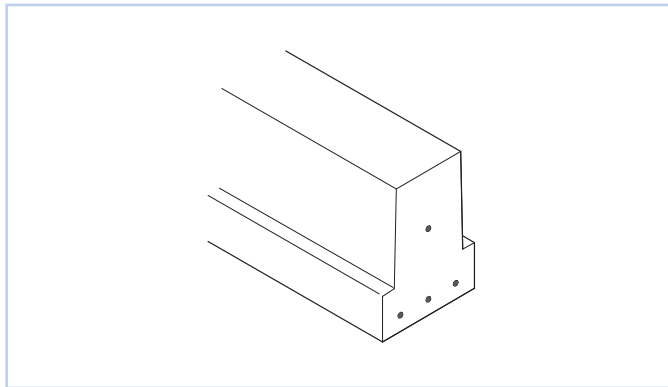


Figure 2.1
T beam unit for beam and block flooring.

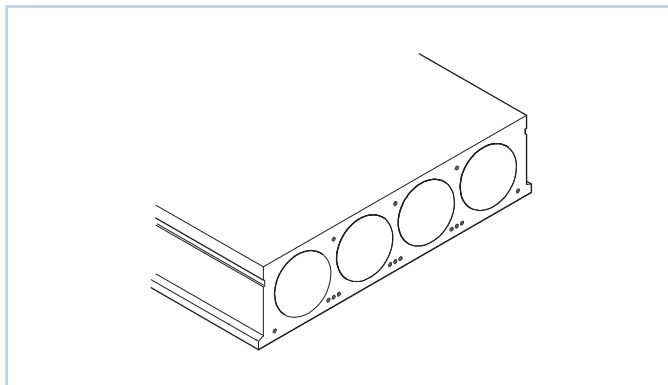


Figure 2.2
Hollowcore flooring unit.

Prestressing is a highly efficient method of manufacturing reinforced precast concrete structural products and is recognised as a modern method of construction. It is most often used in the manufacture of products offsite in factory-controlled conditions, to strict design criteria. The design principle behind prestressed concrete is that, by inducing compressive and bending stresses through high-strength steel wires or strands in a concrete member during or after manufacture, these stresses will approximately balance the tensile and bending stresses imposed in the member during service. This increases the structural efficiency of products. The following section gives a brief introduction to prestressing. In this Code of Practice, particular emphasis is put on areas where special consideration to safety is required.

This Section looks at how the manufacturing and design process are combined in the creation of prestressed structural products.

2.1 Manufacture of prestressed concrete

The manufacturing process has several stages, including:

- Multiple high-yield steel wires or strands are set to a predetermined wire pattern within the concrete section. They may be the sole reinforcement in the section or may be supplemented by normal reinforcement to resist all combinations of load effects.
- The wires/strands are extended to a predetermined load by hydraulic equipment, and the ends are clamped.
- Concrete is poured around the wires/strands, the concrete shape being formed by the mould. For some products the shape of the concrete is achieved by the use of slip form or extrusion casting machines.
- The concrete is allowed to cure in a controlled temperature and humidity environment.
- As the concrete matures it is monitored to ensure sufficient strength development to allow transfer of the prestress.
- The clamped ends are released, thereby transferring the prestressing force held in the wires/strands into the concrete member as the extended wires/strands try to return to their original length. The wire/strands are cut at the ends of the elements and a state of equilibrium of internal forces is attained in the section.
- The concrete matures further until the product is deemed ready for incorporation into a structure.

2.2 Design of prestressed manufacture equipment

Prestressing equipment across the industry varies in age. Some equipment is only recently installed, whilst other equipment can be in excess of 40 years old but still be producing product in a safe manner. However, due to the design of some equipment not all of the controls recorded within this Code are possible. In these instances, the controls implemented to support safe operation need to be recorded during the risk assessment process. The risk assessment will need to demonstrate the degree of consideration and thought to introduce the Code requirements and achieve the highest level of safety possible for the equipment being used, i.e., the risk assessment process is used as justification for the accepted controls and/or the increased safety controls implemented to support weaker standards.

During the design and development of new stressing equipment full consideration should be given to the Code. This requirement is extended to major refurbishments of existing equipment and the installation of second-hand equipment.

2.3 Prestressed concrete design

To an engineer responsible for the design of a concrete structure or building element, prestressing refers to the practice of inducing a beneficial stress or load effect into an element or part of the structure to counter the stresses or load effects that occur during the service life of the structure. As a result, elements can be made more slender, i.e., longer and lighter, providing opportunity for offsite manufacture and savings in cost or programme by prefabrication.

The types of reinforcement (wire/strand) used for prestressing are discussed in Section 4. Prestressing can be carried out at different stages of the construction or manufacturing process. The most common, which is carried out in a manufacturing environment, is the prestressing of reinforcement before the element is cast (known as pretensioning).

Short elements may be cast in a mould and these include beams, lintels, sleepers or solid slabs and walls. Total stressing loads may be relatively small, and it is possible to use the mould to resist the jacking forces arising from extending the wire/strand. However, the procedures for safe prestressing should be followed in all cases.

Longer linear elements such as bridge beams, hollowcore flooring units and long-span roof elements are typically cast in a long prestressing bed. The wire/strand is extended by a predetermined amount between abutments (jacking points). This force can be over 1500 tonnes and is almost always part of a production process for 'standard' precast elements. Significant investment is required to construct the abutments and install the plant and machinery to extend the wire/strand, so commercial viability depends on repetition and standardisation to ensure volume production.

2.4 Design responsibility

Design of prestressed elements should be carried out in consultation with a Chartered Engineer competent in prestressed concrete design. This is frequently someone who is appointed by the manufacturer of precast prestressed products to design a product to a particular performance specification.

This means in practice that the manufacturer's design process is clearly set out to provide design and production information to control stressing and de-stressing of reinforcement. This generates information that is conveyed by drawings and production schedules.

Clear design statements are required for:

1. The total design force to be applied to the element and that at the jack heads.
2. The wire or strand arrangement and any order of stressing individual or groups of wires or strands.
3. The means of validating the force in each wire/strand. The load in the wire/strand should be checked by calculation (giving extension) or by calibrated gauge (giving a load reading).
4. Information on the properties of the materials being used and the strength characteristics for reinforcement.
5. The strength of the concrete required to be attained at the time of transfer of the prestress.
6. The final strength required in the concrete at the time the element is to be put into service or assembled in the building.

The type of product often dictates the process and documentation to satisfy the above requirements, but they should be verifiable in any design audit. The above design verification is therefore embodied in the process descriptions, maintenance processes and operational procedures described in other sections of this Code.

2.5 Product type testing

Design verification is often carried out by testing prestressed elements in order to ensure that new or improved products meet the predicted requirements of design. This then forms the basis of continuous quality control to ensure consistency in manufacture.

2.6 Constituents

Prestressed concrete products are a combination of concrete and reinforcement, and this requires a careful understanding of the physical properties of both materials. For steel this principally relates to strength consistency and predictable load characteristics.

2.6.1 Concrete

Concrete is principally a combination of sand, aggregates, cement and water. There needs to be a special consideration of its physical properties for all phases of its life from when it is a wet plastic mouldable material to a highly resistant compression material. Additives are often included to improve concrete properties. Consideration should be given to how it gains strength and maintains a durable and fire protective barrier to the steel, and how it behaves under sustained loading. The choice of constituent materials and their proportions all have an influence.

2.6.2 Prestressing steel

The steel used for prestressing concrete is either high-tensile wire or high-tensile strand and needs to meet the requirements of BS 5896.

2.7 Production of prestressed concrete products

A typical generic arrangement for the manufacture of prestressed concrete products is illustrated in the following flow chart that relates to flooring (Figure 2.3).

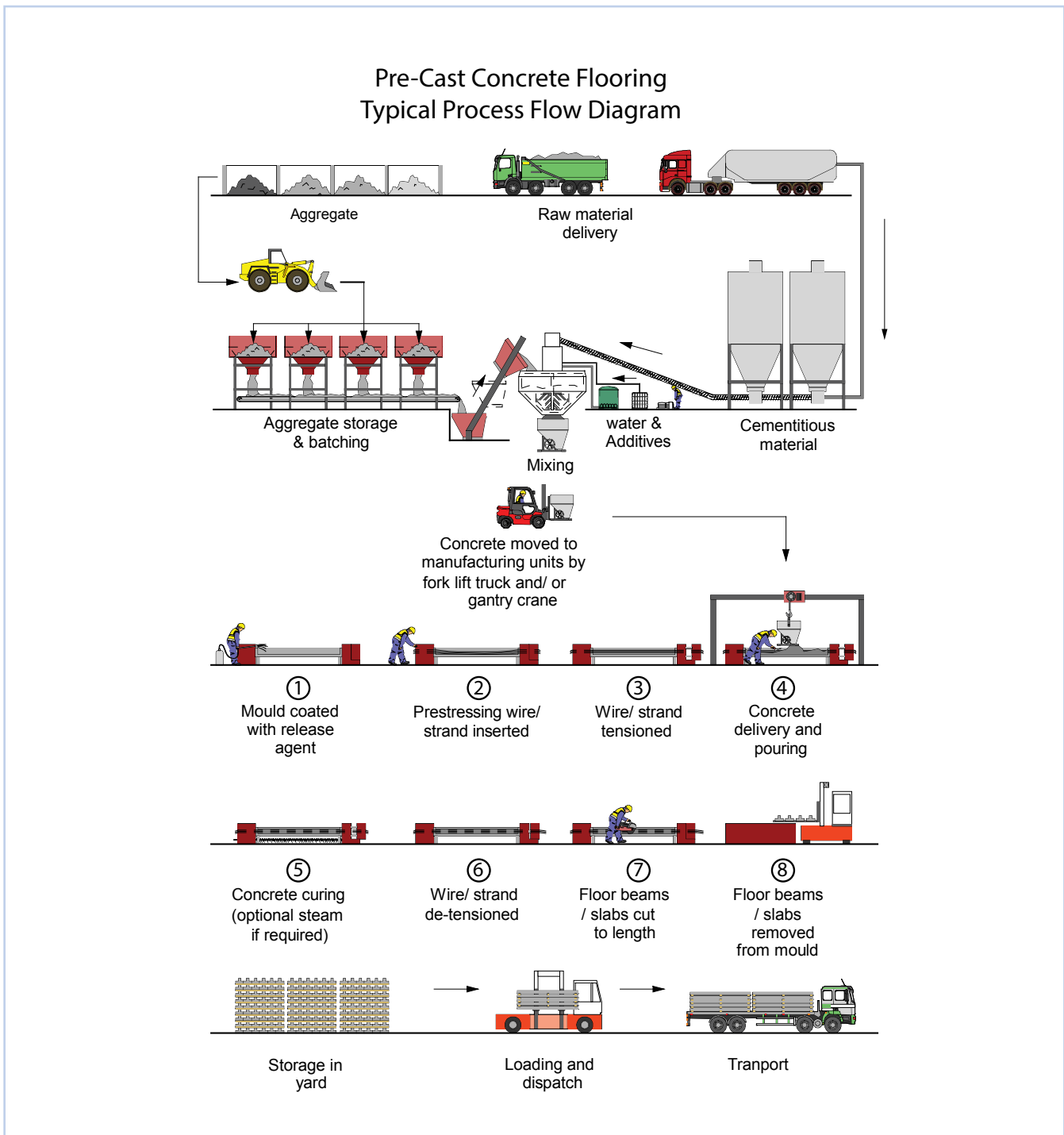


Figure 2.3
Typical flow process diagram for the manufacture of prestressed concrete flooring.

Note: Products that may be prestressed include lintels, beams, hollowcore flooring, wall panelling and bridge beams.

3 Stressing process and equipment

There are two main methods of stressing:

3.1 Single wire/strand stressing

In single wire/strand stressing each wire/strand is stressed individually by using a special jack and prestressing pump that is connected to the jack with a flexible hose. The strand/wire is gripped for pulling by internal wedges and extended by the jack to a predetermined load (Figures 3.1 and 3.2).



Figure 3.1
Single wire/strand stressing with a jack.



Figure 3.2
Jack and stressing pump - mobile set up which incorporates a jack balance.

3.2 Multi-stressing system

Multi-stressing is a method whereby the full complement of wire/strand, which is held in position at the live end of the bed/mould, is stressed together in one operation (Figure 3.3).

Where there's a need for connection and disconnection of flexible hydraulic hoses to stressing systems, hose safety whip check retainers should be fitted to prevent whiplash hazards from a connection failure. (Figure 3.4).

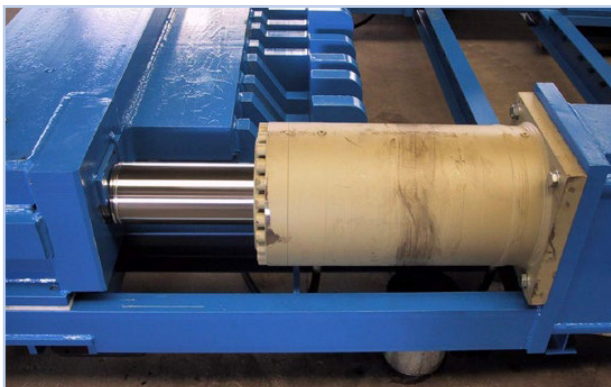


Figure 3.3
Hydraulic stressing mechanism on mould for multi-stressing.



Figure 3.4
Example whip check.

3.3 Maintenance

When stressing jacks are used the internal wedges must be regularly checked and serviced in a similar way to the barrels and wedges used on the bed (see Section 5).

Multi-stressing systems require less maintenance; however periodic inspection of all components, particularly the hoses and couplers, is required, together with checks for fatigue cracks in the steel structure and surrounding concrete.

Care is necessary when disconnecting and reconnecting hoses to avoid contamination. Both pumps and jacks should be kept clean and require regular servicing. Jacks should be re-calibrated after a maximum period of six months. Calibration of the jacking system is not required if the measurement for stressing is only based on wire extension and not tension applied by the jack. The current calibration certificate should be on file for reference and a clear indication given to the stressing operative of the pressure needed to achieve the correct load in the strand/wire.

Manufacturer's maintenance instructions should be followed, with oil levels being checked as part of the regular maintenance routine. In house inspection and maintenance records need to include relevant elements of the manufactures instruction to ensure that they are not missed.

To support the safe completion of maintenance activities; safe systems of work need to be developed and confirmed by all relevant maintenance staff. An example format for a safe system of work is included in Appendix 4.

Regular services should include filter and oil changes, relief valve checks and a system check to ensure that the pressure can be held in accordance with the manufacturer's instructions. All inspections and maintenance requirements should be recorded on the location's scheme of inspection (see Section 1).

In addition to the routine inspection of the pulling wedges, the system should be re-calibrated after any component changes to the pump or jack.

Any hydraulic leakage should be repaired immediately, or the equipment taken out of service.

3.4 Moulds and stressing abutments

3.4.1 Moulds

Moulds can be either separate from the stressing elements so that they sit between the tensioned abutments and merely act as the shape former, or they can be designed to be integral with the abutment ends so that part of the stress resistance is taken through the body of the mould itself.

3.4.2 Abutments

Abutments can vary in size, shape and complexity depending upon the forces they need to resist, and the shape of the elements being cast. For long prestressing beds used in the manufacture of hollow core flooring and bridge beams, the foundation depth needed to resist the overturning motion of the prestress, which can be up to 1500 tonnes, can be several metres deep.

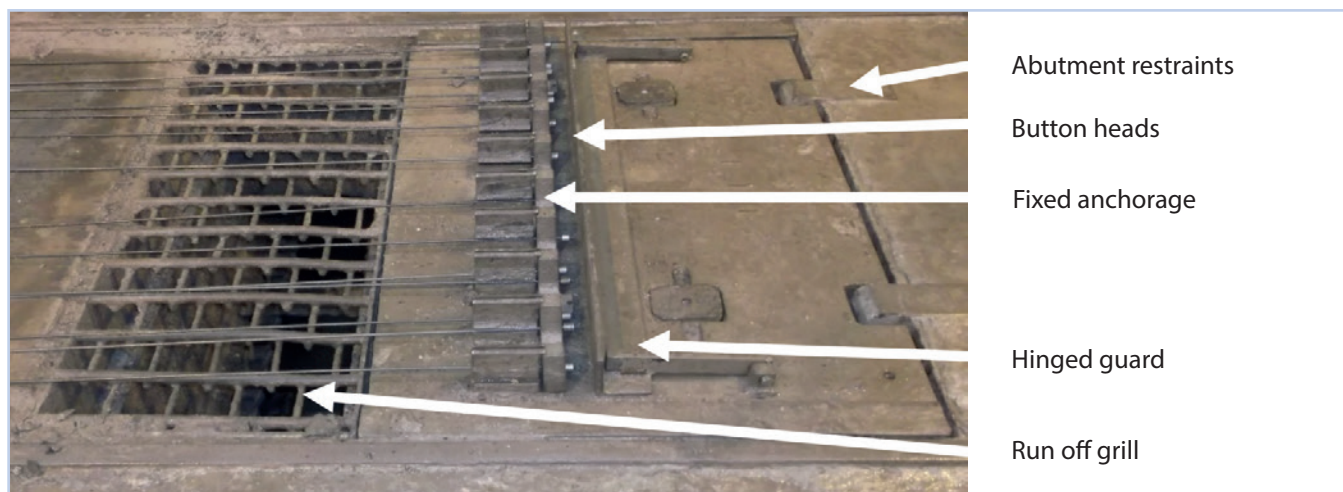


Figure 3.5
Abutment at end of hollowcore flooring casting bed.

3.4.3 Inspection and maintenance

In all cases it is essential that the structural integrity of the moulds and stressing abutments is maintained. Each company should develop its own certification and testing policy as part of the safe stressing operation.

Where possible, verification of the safe working capacity of the moulds and stressing abutments must be obtained from the manufacturer, or independent verification obtained from a suitably qualified engineer. Multi-stressing equipment should not be capable of exceeding the abutment design limits.



Figure 3.6
SWL and plate added to an old bed following independent verification.

Any changes to the set loads and strand/wire positions should be approved in writing by the engineer responsible.

Inspection of moulds and stressing abutments must form part of the regular inspection regime of a suitably qualified engineer and should be carried out at the recommended intervals. Permanent anchorage points at both ends of the stressing bed should also be cleaned and examined by a competent person at periodic intervals to ensure their integrity.

Recommended inspection periods for external/independent inspection and NDT testing by a suitable qualified engineer should be completed in line with the recommendations from the initial inspection, unless there is concern that mouldage and stressing abutments may have deteriorated. It is recommended that the frequency of these inspections should not exceed five years.

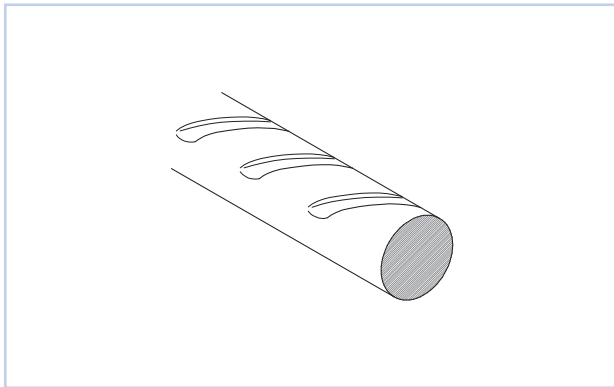
Examples of inspection and test during NDT testing should include:

- A full clean/removal of all concrete build-up/sand blast of the visible mouldage and abutments at both ends
- Visual inspection for general condition
- Application of magnetic particle inspection to help identify any cracks in welds/steelwork under tension during the stressing process
- Review of supporting steel/concrete foundation to identify possible weakening
- Review for any signs of movement/twisting in all elements

The frequency of in-house inspections completed by suitable qualified maintenance engineers needs to be decided through the risk assessment process (considering the long-term effects of the materials on the production equipment, age, condition, effects of environmental influences, number of uses, etc.). The application of vibration, depending on the concrete compacting method chosen, can have a serious effect on the life expectancy and condition of the moulds and abutments. Where possible self-compacting concrete should be used (see Section 7), which reduces the risk and damage caused by vibration and can also increase the life expectancy of a mould.

It is essential that full inspection and maintenance records are maintained for all equipment used in the stressing process, including traceability of defects found through to confirmation of repairs. See the example inspection records in Appendix 2 to support the development of suitable inspection formats.

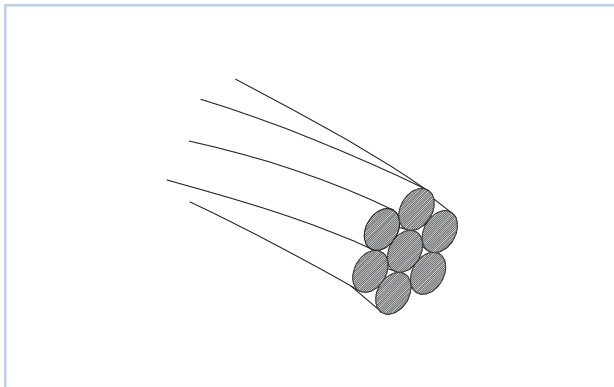
4 Wire and strand



4.1 Wire

Wire is a single solid length of steel that may be plain or indented and is wound into large diameter coils.

Figure 4.1
Indented wire.



4.2 Strand

Strand consists of a number of cold-drawn wires spun together and then wound into coils.

Figure 4.2
Strand.

4.3 Purchase orders

Steel should be ordered according to the standards that are applicable for the concrete product that is being manufactured. In most cases this means that steel should be ordered to the British Standard for prestressing steel, *BS 5896 High tensile steel wire and strand for the prestressing of concrete – Specification*.

Steel should be purchased only from suppliers that are on a company's approved suppliers list. It is a requirement of the British Standard for prestressing steels that steel suppliers operate a quality management system to BS EN ISO 9001. Traceability of steel is important, and suppliers should be able to produce an up-to-date certification showing compliance with BS EN ISO 9001.

There is currently no harmonised European standard for prestressing steels and so there is no CE marking covering prestressing wire and strand.

To avoid any confusion, steel should be ordered using the 'steel designation' as specified within BS 5896 and the designation should consist of:

1. The number of the standard, i.e., BS 5896.
2. The steel name consisting of the letter Y for prestressing steel.
3. The nominal tensile strength in MPa.
4. The letter C for cold drawn wire, or S7 for seven-wire strand.
5. The nominal diameter of the wire/strand in mm.
6. The type of indent. For wire this is T1 (triple indent/chevron) or T2 (Belgian indent), and for strand the letter I if it is to be indented.

For example, if ordering 5mm triple indented/chevron wire the designation would be BS 5896 Y 1770 C 5.0 T1.

The designations of the most common sizes ordered in the UK are given below:

- **5mm** (1770 grade) indented wire BS 5896 Y 1770 C 5.0 T1
 - **7mm** (1670 grade) indented wire BS 5896 Y 1670 C 7.0 T1
 - **9.3mm** (1770 grade) plain strand BS 5896-Y 1770 S7-9.3
 - **9.3mm** (1770 grade) indented strand BS 5896 Y1770 S7-9.3 I
 - **12.5mm** (1770 grade) plain strand BS 5896-Y 1770 S7-12.5
-

Other designations commonly used include:

- **12.9mm** (1860 grade) plain strand BS 5896 Y1860 S7-12.9
 - **15.7mm** (1860 grade) plain strand BS 5896 Y1860 S7-15.7
-

If ordering other sizes or different steel grades, then refer to BS 5896:2012 for full information of the designation to be used.

With respect to welds within wire, BS 5896:2012 states that:

“Wire shall contain no welds in the product as supplied by the manufacturer. Strands with normal production lengths may contain welds made in the individual wires before cold drawing but shall not contain any welds made during or after cold drawing. Not more than one weld in any component wire shall be permitted in any 50m of strand.”

4.4 Delivery

Each coil or bundle of wire or strand should carry a label giving:

- The steel designation (e.g., BS 5896 Y 1770 C 5.0 T1).
- The coil number.
- The manufacturer’s name and manufacturing site.

If requested the steel supplier should supply test certificates for each coil delivered. BS 5896 does not require test certificates to be supplied unless the customer requests it; however, it is good practice to request this.

4.5 Offloading and handling

Wire and strand can be offloaded from trucks using an overhead crane or by forklift trucks. The coils are usually 2 - 4 tonnes each, so care must be taken to handle them safely. The supplier of the steel should be consulted where any doubt exists as to the safe handling of the product. Additional information on this topic is available in the HSE publication HSG 246, Safety in the storage and handling of steel and other metal stock (see www.hse.gov.uk/pubns/priced/hsg246.pdf). It is expected that a documented specific safe system is in place to clearly list the stages for safe offloading and handling of steel, including pictures to support the expected processes. This will include any relevant elements from HSG 246.

4.5.1 Wire

Wire is delivered in large coils on the bed of the truck; they can be unloaded using an overhead crane with lifting slings made of synthetic webbing - on no account should wire rope be used. If using chain slings extra care must be taken to ensure that the wire is not damaged. If using a forklift truck care must be taken to not damage the wire by pushing the fork into the coil or by accidentally 'catching' wires during the lifting process.

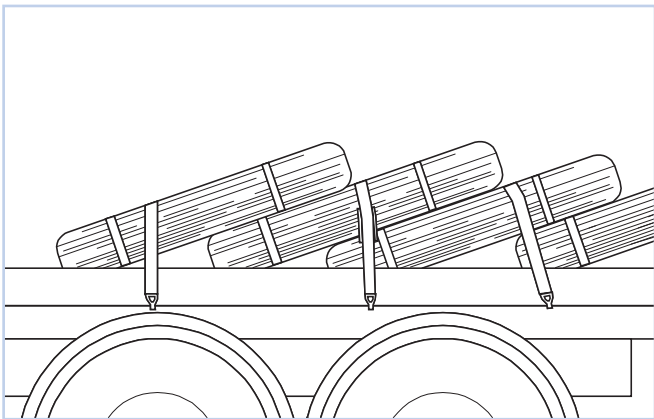


Figure 4.4
Delivery of wire.

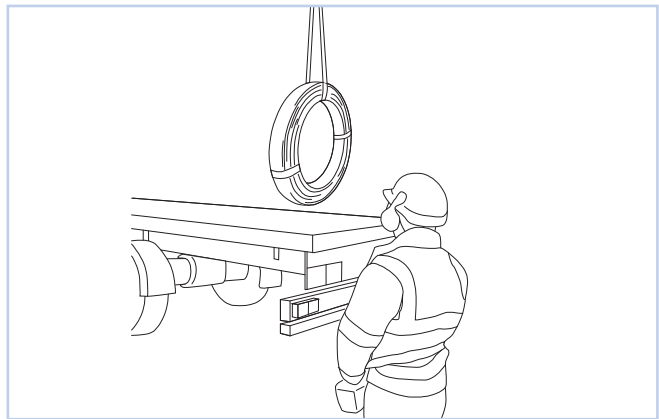


Figure 4.5
Wire unloaded by crane using lifting sling.

4.5.2 Strand

Strand is delivered in coils that will be laid flat ('eye to the sky') or on edge ('eye to the side').

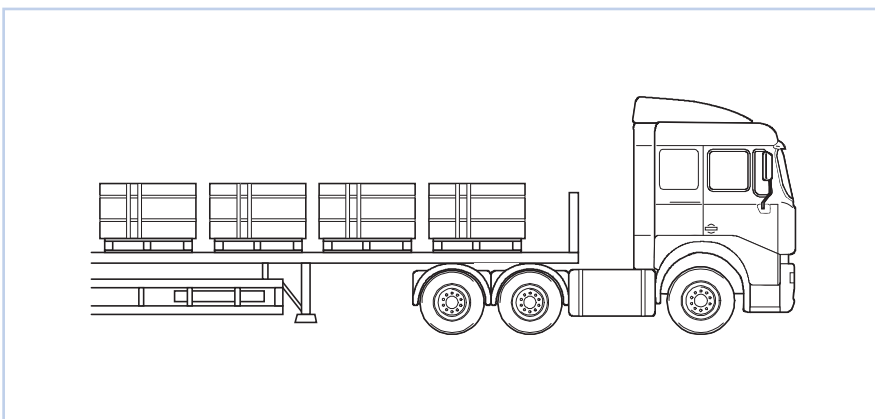


Figure 4.6
Delivery of strand coils laid 'eye to the sky'.



Figure 4.7
Strand coil laid 'eye to the sky'.

Strand is best handled using a forklift truck; if an overhead crane is used **it is important that the coils are not lifted with slings** as this will distort them and can cause the coils to collapse. If unloading with an overhead crane a lifting bar or C hook must be used. A reminder of the safe handling of strand is contained on the caution label attached to most coils.



Figure 4.8
Label attached to strand as a reminder of safe handling.

4.6 Storing wire and strand

Wire/strand should be protected when in proximity to welding operations as welding sparks can cause damage and create weak spots in the wire/strand that may lead to failure.

4.6.1 Wire

Wire should be stored where it will not be excessively exposed to the elements in an area where it will be free from contamination and safe from being accidentally damaged (for example by a truck). It could be kept off the ground to encourage ventilation and drainage.

One should ensure that the wire is stacked evenly/level and safely and cannot be damaged by the storage conditions and location where it is stored.

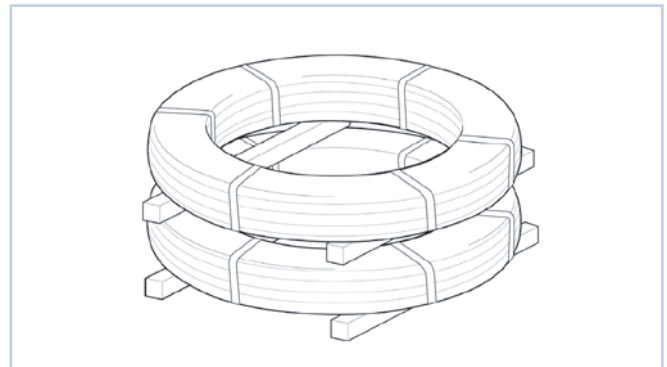


Figure 4.9
Example of storage method for wire on timber batons.



Figure 4.10
Wire storage in protected area, under cover and no standing water, etc..



Figure 4.11
Poor storage - Risk of wire damage from concrete batons and the elements.



Figure 4.12
Cover lifted by forklift truck protecting wire from the elements.

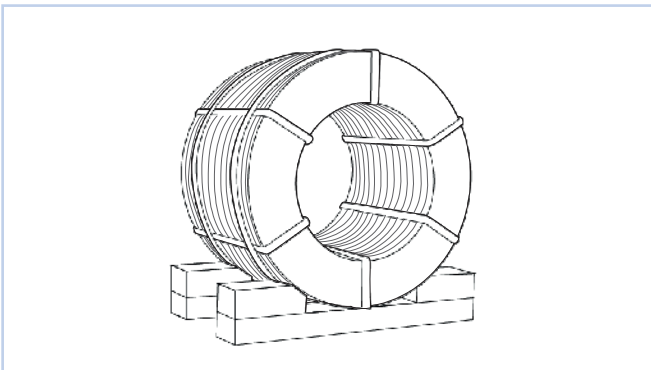


Figure 4.13
Eye-to-the-side coil supported on timber bearers.

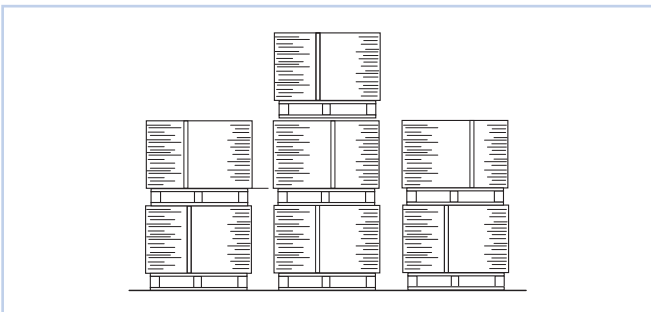


Figure 4.14
Eye-to-the-sky strand stacked off the ground.

4.6.2 Strand

Strand can be stored 'eye to the side' or 'eye to the sky' (Figures 4.13 and 4.14) and should be placed where it will not be excessively exposed to the elements in an area where it will be free from contamination and safe from being accidentally damaged (for example by a truck). If at all possible, it should be kept 'off the ground' to encourage ventilation and drainage.

The most stable way is for coils to be placed 'eye to the sky'; this can also provide the opportunity to stack the coils up to three high. When stacking care must be taken to ensure that the ground is strong enough to take the weight and that the stacks are stable and secure. Refer to HSG 246 and confirm that coils are secured so they cannot fall or roll.

If storing coils 'eye to the side' care should be taken to ensure that the coils are prevented from rolling by using chocks or other means.

4.7 Stock rotation

Good stock management is important as all steel products will rust over time and so it is wise to adopt first in/first out stock rotation. To prevent excessive rusting, consideration should be given to how long the steel is stored and under what conditions. If the steel is to be stored for a long time, some form of extra protection should be provided, for example sheeting or storing under cover. If there is any concern with the condition of stock contact the supplier for guidance.

4.8 Cutting strapping

Strand and wire are always supplied with steel transit strapping and may also be wrapped. If the steel is wrapped it is acceptable to remove the outside steel transit straps and wrapping before placing the coils into a dispenser. Under no circumstances should internal securing straps holding the coil together be removed **before** the coil is placed in a dispenser (in the case of strand) or in the place where it will be used (in the case of wire).

When cut the steel banding is sharp and has significant spring, which can cause an injury. Eye protection, gloves and arm protection should be worn, and the correct banding cutters should be used. The steel straps must be cut using a special steel-strapping cutter; straps must not be cut using an angle grinder, hammer and chisel, or cutting torch.



Figure 4.15
Specialist steel strap cutter.

4.9 Dispensing wire and strand

There are a number of different ways of dispensing or de-coiling wire and strand. For example, wire can be dispensed using a 'hangman's noose' arrangement, or from a 'lobster pot'.

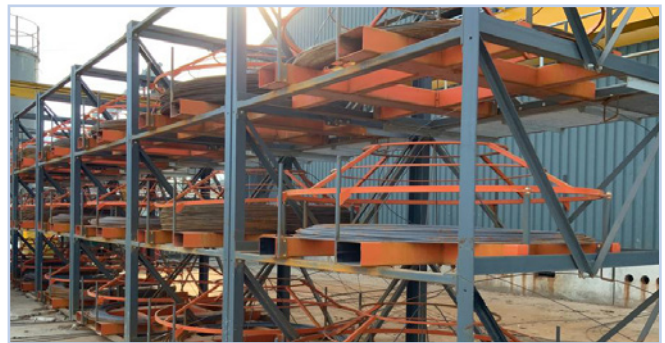


Figure 4.16
Ground lobster pot style cage with rotating eye easing wire flow and lobster pot racking used in restricted spaces also reducing wire contamination.



Figure 4.17
Rotating eye reducing manual handling and tangles during wire pulling.

Strand must always be dispensed using a coil dispenser; it is good practice to use a dispenser that has an anti-tangling design such as a bar or 'double cone' in the centre.

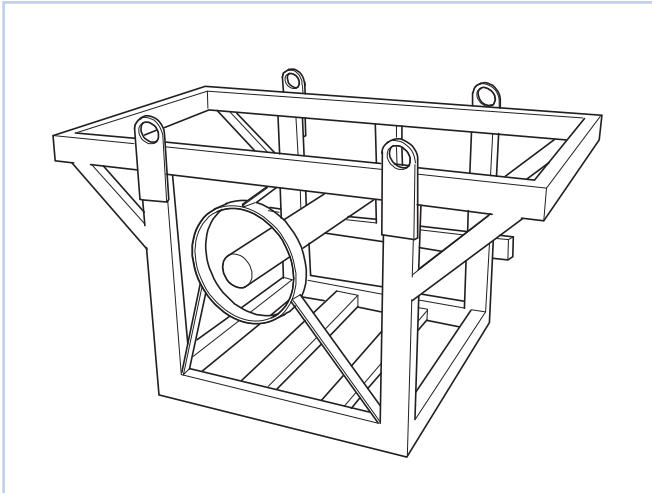


Figure 4.18
Strand dispenser with cone in centre to help prevent tangling.



Figure 4.19
Strand dispenser with extended nose to help prevent tangling.

4.9.1 Wire

It is good practice when dispensing wire to identify the top of the coil and pull from that end. Most manufacturers will identify the end of the coil with a tag/rubber bung or label.

The ground where the coil is placed for de-coiling should be flat and free draining; water should not be allowed to puddle under the coils as this will increase the risk that the steel will rust quickly. It is good practice to raise the coil off the ground. Dispensing the wire is facilitated by pulling from a high point, through a ring above the centre of the coil.

4.9.2 Damaged or kinked wire

During the handling, dispensing (or wiring up) operation operatives should carefully inspect the coils for any damaged wires, kinked wires or excessive corrosion. Where this occurs the damaged section should always be cut away and must **not** be used in production.



Figure 4.20
Wire kinked while still coiled.



Figure 4.21
Wire/strand kinked on stressing bed.

4.9.3 Strand

To prevent tangling of strand it is very important that the coils are loaded into the dispenser and pulled in the correct direction. The direction of pull will depend on whether the steel is left or right hand lay; this is determined by the direction of strand winding. Suppliers should always identify the end of the strand and show the direction of pull on the label. However, if the direction is not shown, or has been lost, it can be worked out using the following rule of thumb:

- If the steel is left hand lay, use your left hand and follow the direction the strand has been wound inside of the coil – your thumb will point in the direction of pull.
- If the steel is right hand lay, use your right hand and follow the direction the steel has been wound inside the coil – again your thumb will show the direction of pull.

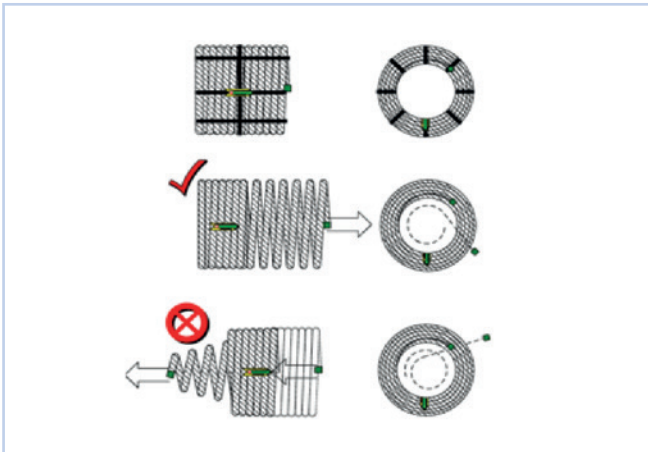


Figure 4.21
Always pull from the end indicated by the green arrow.

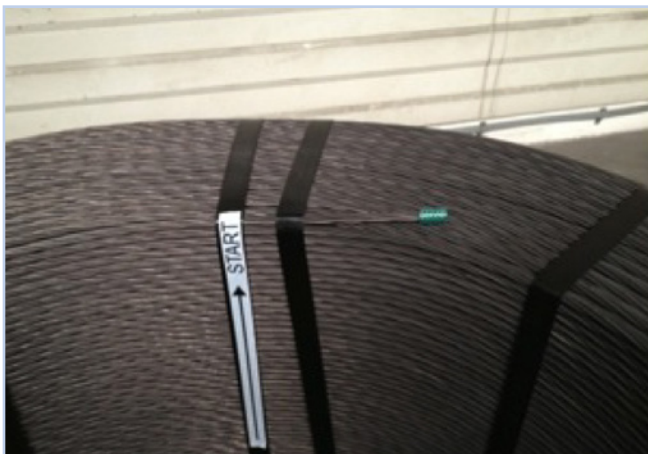


Figure 4.23
Coils of strand showing indications of where to start pulling.

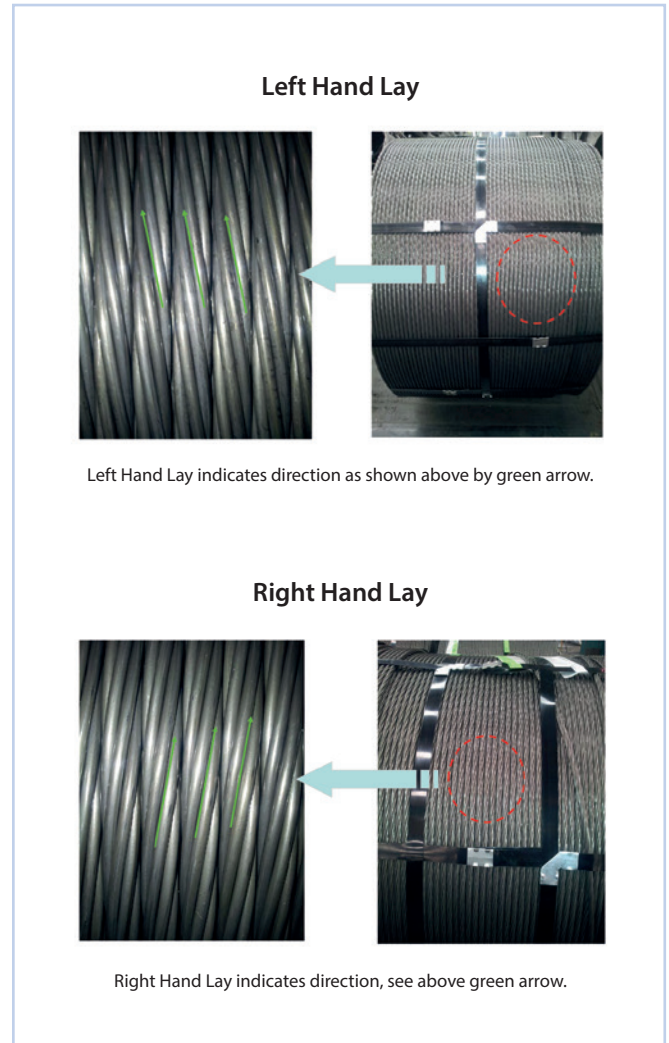


Figure 4.22
Coils of strand showing direction of lay.

4.9.4 Hot metal working

Heat applied to a stressed strand/wire can result in elongation and failure. Hot metal working should not at any time be carried out near any strand/wire, particularly if it has been stressed. Should work of this nature be required the strand/wire should be de-tensioned and protected. Also, care should be taken with electric cable as it may cause a short or arc which could damage the strand/wire.

5 Wiring up the bed

5.1 Running wires/strand

There are several methods that can be employed in running the wires/strands down a stressing bed; the method employed will depend on the site and the product.

They can be run after dispensing and cutting, or they can be dispensed straight into the bed and cut accordingly. It is important not to damage the wire/strand at any time as this could cause failures during the stressing process. All wires/strands should be checked to ensure that they are in line, are not crossed and have no tangles, kinks or damage and they must be correctly positioned on the bridges at both ends of the bed.

It is imperative that when the wire/strand is being pulled from the cage/lobster pot that it remains as free as possible from yard and shop floor slurry, water and dust etc.. This can be achieved by reducing the free running length of the wire/strand to a minimum and ensuring that where wire/strand comes into contact with the surface it is as clean as possible. The cleaner the wire and strand the less dust and slurry can be collected on the wedges, which has the potential for decreasing the life of the wedges (see Section 6.3).

Running wires should be without the use of human effort wherever possible.

Due to the bed lengths it is common practice to pull or tow a single wire/strand, or several together, with a type of pulling trolley, attachment on a forklift truck or other suitably adapted equipment. When pulled mechanically the wire/strand should be allowed to rotate freely. Where forklift trucks or similar equipment are used as the means by which the pulling is achieved, the potential consequences of a wire snagging, or breaking under tension, should be formally assessed and recorded in the relevant risk assessment and in consultation with the equipment supplier if required.

When using assisted pulling a second person or system needs to be included to observe the wire being dispensed and to be able to warn/stop pulling. This can be achieved through an agreed communication method, including the sounding of a hooter or the use of a light/audible warning on the pulling device. The speed of pulling should be controlled/slow enough to enable the observer/pulling equipment operative to react before damage can occur.

When pulled by hand a wire pulling handle could help to eliminate contact with the rotating wire. If contact with the wire cannot be avoided the correct gloves with palm protection should be used so that the lay of the strand does not trap the material of the glove or skin and cause a sprain injury or worse. Be aware that the wire can also get tangled with a hi-visibility vest and hair; safety controls need to be identified and introduced during the risk assessment process. Wire pulling must, wherever possible, only be completed from the ground level with good housekeeping standards to reduce slip and trip incidents. Controls introduced to reduce slip, trip and fall hazards must be recorded on the risk assessment linked to wire pulling.

When pulling wire/strand from a dispenser either by hand or with a machine it is important to allow it to rotate freely. If restrained by grabbing or clamping the strand will build up pressure and can cause injury and damage.

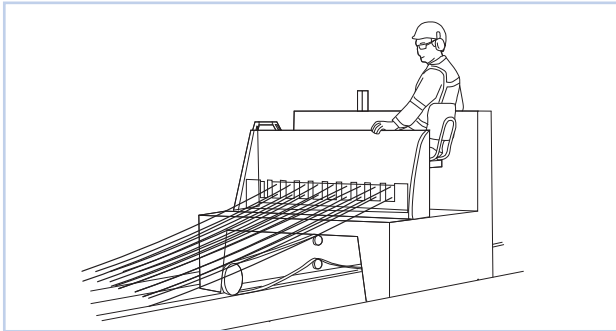


Figure 5.1
Pulling by machine.

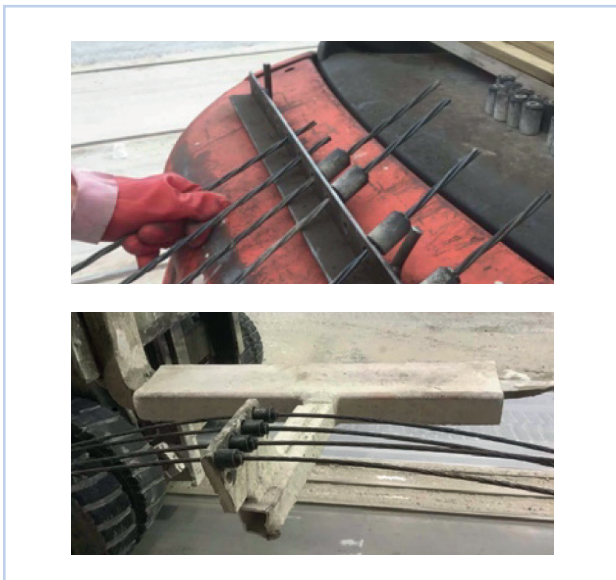


Figure 5.2
Pulling with fabricated attachments on forklift truck rear and fork.



Figure 5.3
Example of tool to allow free rotation of wire when hand pulling.

5.2 Wire / Strand Pushers / Rabbits

Wire/strand pushers and 'rabbits' can be used to push or pull the wire/strand down a track or area away from the beds. Care is required with all systems to ensure that the wire/strand is able to rotate freely with the operative having the ability to stop the process if a tangle develops. The track and drive systems must be effectively controlled with suitable guarding to protect personnel from any rogue flailing wire/strand. The pulling system needs to comply with all statutory guarding and isolation requirements in order to prevent access to any nip points during wire preparation, dispensing and maintenance operations.



Figure 5.4
Rabbit mechanism on raised track for pulling pre-determined lengths of wire/strand.

5.3 Cutting wire/strand

The material used in the production of the stressing wire/strand is high-tensile steel and as such is difficult to cut. The following details apply to cutting wires/strands using either an angle grinder, plasma torch, gas torch or bolt cropper.

All methods have safety implications that can change depending in which circumstances they are used. Careful consideration should be given to ensure that the safest means possible is used for cutting wires given the specific site circumstances. Stressed strand poses an added risk as individual strands have a tendency to unwind as they are cut and behave in an unpredictable manner, putting the operative in danger.

The end of stressed wires should not be cut due to the increased risk of slippage of the wedge grip. The strand/wire length should be such that when stressed the guards can be positioned without needing to shorten the stressed wires. This requirement needs to be included during the risk assessment process with modification to guarding, etc. made, where required, to eliminate the cutting of stressed wires.

In case of emergency when stressed wire/strand needs to be de-stressed in an unplanned release extra consideration must be given to the position of the cut in relation to the amount of free wire/strand present and its direction of travel when cut. When deciding how to control the risks during cutting attention should be paid to guarding, restraint and operative position.

5.4 Bolt croppers

Bolt croppers can be manual, hydraulic or pneumatically operated; the size should be determined by the diameter of the steel being cut. PPE, including gloves, Grade 1 impact lens goggles/mask and protective clothing is recommended, with additional precautions being necessary with pneumatically operated equipment due to the use of compressed air.

5.5 Hot cutting / Electrode

Hot cutting is the least preferred method and should be avoided to cut free strand or wire before stressing is completed since the heat affected zone may extend from the cut point to the area of grip by the wedges, with the potential for weakening the area of wire/strand. Croppers or an abrasive wheel should be used.

5.6 Angle grinders

The most commonly used cutter, an angle grinder, requires suitable PPE including gloves, Grade 1 impact goggles/mask and protective clothing. Normal safety glasses do not meet the legal requirements. When cutting wire/strand it should be placed on a timber packing, if close to the ground, as opposed to concrete or steel to minimise the risk of flying debris. This also extends the life of the cutting disc.

6 Barrels and wedges

Barrels and wedges (B&Ws) are placed over both ends of the wires/strands once they have been passed through the locating holes in the stressing heads/abutments. Used in combination they lock to grip the ends to form the main resistor to the wire/strand slipping through the locating hole in the stressing heads after stressing.

6.1 Procurement of stressing components

All stressing equipment and anchors used in the precast concrete industry should be manufactured under a certified quality management system and to the manufacturer's design specifications. As a minimum, precast wedges and barrels should be marked with the manufacturer's name, maximum load rating and, where space allows, the batch traceability marking. The manufacturer should be externally certified to a recognised Quality Management System, e.g., BS EN ISO 9001. The manufacturer's certificate of conformity to their inspection plan and quality management procedures should be available upon request.

Components from different manufacturers **cannot be mixed** and control systems should be in place to ensure that mixing does not take place.

6.2 Storage

The B&Ws should be stored in a dry atmosphere, away from moisture and not immersed in oil. Methods of storage following inspection and cleaning are shown in Figure 6.1.

The wear rate on a set of wedges should be equal to avoid unequal pressure being applied on the strand/wire when they grip the steel.



Figure 6.1
Barrel dispensers.

6.3 Inspection, cleaning and lubrication

A dirty or worn wedge can fail by allowing the wire/strand to slip out of the anchor under load, with catastrophic consequences.

The rate of cleaning and inspection of B&Ws will differ from site to site depending on the environment in which it is used (see Section 5.1 relating to reducing contamination on wire/strand during running) and the frequency of use. Ideally the B&Ws should be cleaned and inspected after every use. If an initial inspection, by a competent person, following each use results in clean and build-up free wedges they may not need a full clean and inspection as detailed below. Any concern must result in a full clean and inspection process being completed.

The location's risk assessment process must be used to record the reasons for the site-specific cleaning and inspection frequency, with a SSOW which clearly describes the local B&W cleaning requirements, including the stages involved. The SSOW should also give clear pass, fail and consult criteria and explain the action to be taken to remove any failed items. It should not be possible for failed items to be returned to use. A competent person should, with reference to the supplier's instructions and in consultation with the supplier, ensure that the B&Ws are cleaned, inspected and lubricated using the correct lubricant as required.

More detailed periodic examinations may also be required to determine if excessive wear, abrasion or corrosion, or the beginning of fatigue cracking has occurred. This may require the use of gauges and microscopes (Figure 6.7).

New B&Ws need to be inspected and cleaned prior to their first use, especially to remove the film of oil used to preserve the new B&Ws during storage.

When cleaning, care should be taken to remove any dirt from the teeth and on the segment joining faces as this will affect the grip's performance. Wedges are supplied with a rubber 'O' ring or steel circlip to hold the segments together. It is important that these are fitted and in good condition to control the wedges during use.

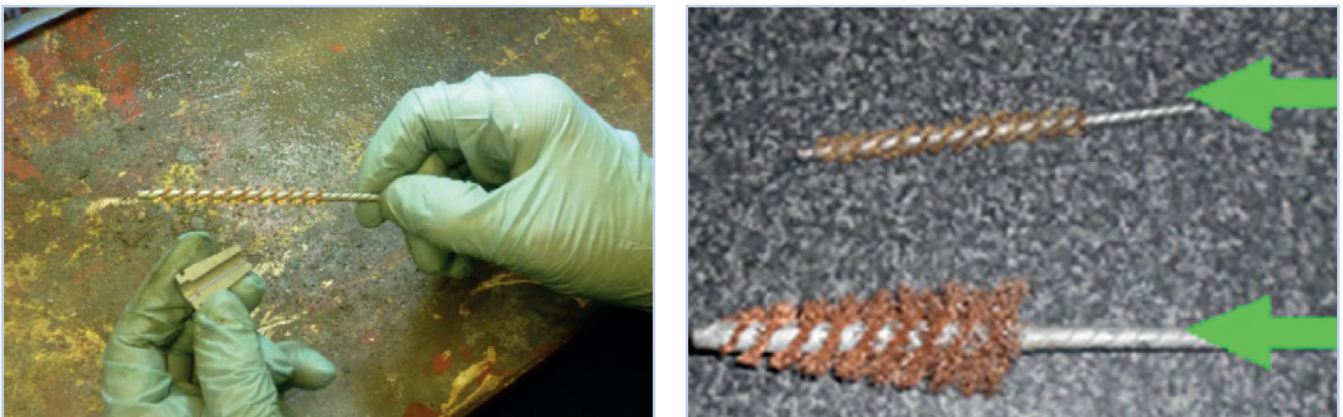


Figure 6.2
Left: Cleaning a wedge, Right: Brushes for cleaning wedges (top) and barrels (bottom).

Barrels should be checked for wear using an appropriate tool. Steel barrel gauges are inserted into the cleaned barrel to confirm the head of the tool does not extend beyond the barrel top and is a tight/snug fit with no sideways play evident (Figure 6.3).



Figure 6.3
Steel barrel insert tools for measuring barrel wear.

All wedges are manufactured using case hardened steels and tooth damage can expose the softer base material which has little or no capacity to grip the hard steel tendons. The wedge teeth should be inspected with great care to ensure that the tooth form is sharp and undamaged and, if not, they should be replaced. Examples of poor wedges are pictured below.



Figure 6.4
Wedges with evidence of slippage.



Figure 6.5
Evidence of cracked wedges.



Springs used in spring-loaded anchors (SLAs) and double-ended joiners (DEJs), which are also known as wire/strand couplers, should be changed regularly, particularly if used on beds that are subject to shock de-tensioning.

Figure 6.6
New spring/damaged spring which would need replacing.

When looked after well, barrels can last for many years. They may, however, eventually suffer from wear, damage and metal fatigue. For precast manufacturers who regularly inspect and frequently replace components, there is reduced likelihood of failure by fatigue.

Inspection of the barrels and wedges must be carried out in good light with the aid of a magnifying glass. These inspections may require the use of more sophisticated equipment, for example a magnifying glass with calibrated reference lines or a magnifying inspection camera/microscope.

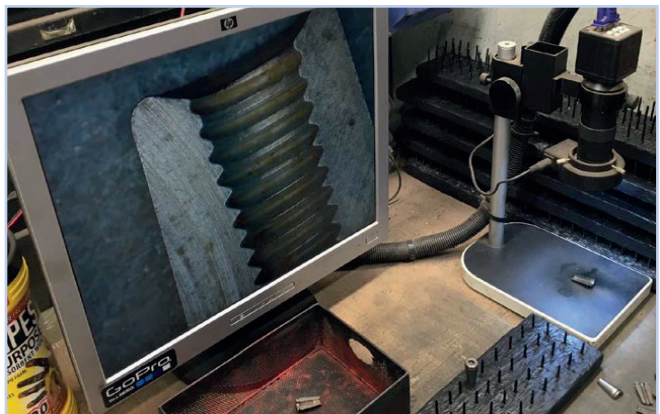


Figure 6.7
Examples of procedure for examining wedges.

Reject items must be disposed of immediately to prevent their reuse. Records of numbers inspected should be maintained to support recognition of an increase/decrease in failures and instigate suitable investigation.

There should be enough trained and competent persons to complete the cleaning and inspection process, to cover for holidays, sickness and other duties. The cleaning process is to be completed by persons whose first priority/operation is to the management of B&Ws. Other trained persons should be used to support cleaning and inspection requirements and provide a quality check on the standards of cleaning and inspection by the main B&W management staff.

Every six months an internal or external validation of the inspection, cleaning and associated documentation should be completed. It is important that suitable facilities for the cleaning and inspection of the B&Ws are in place, which represents the importance of the task and expected standards, i.e., high standard of housekeeping, clear of any tools and store items not linked to the cleaning process, well-lit, etc..

The facility should be arranged so that the cleaning and inspection stages listed above flow around the room/area. Extraction should be provided for the lubrication process leading up to rebuild and labelled storage ready for use. There should be a marking arrangement for B&Ws going through the process with only cleaned and inspected B&Ws being able to be collected for use. The room should have poster information to support the minimum/expected standards of cleaning and inspection.

6.4 Barrels and wedges

Wire/strand restraints come in five versions:

- Open barrel and wedges
- Enclosed (spring-loaded) wedges
- Bayonet caps
- Wire/strand couplers (double ended joints)
- Button headings

Manufacturers of wedges mark them with the wire/strand size and the barrels are marked with a maximum stressing load capacity where the unit is of a suitable size. This is not the site stressing load - reference to the site's design engineers should be made to determine the required load. They should also be marked with a traceability code; the marking is limited by the size of the unit.



Figure 6.8
Barrel and wedge markings.

6.4.1 Open barrels and wedges

Open barrels and grip wedges are the most common in use at the live end with a jack that has a secondary function to lock off the wedge using a small piston at the end of the jack. They can also be used at the dead end. However, care is necessary to ensure that the wedge is 'locked off' by tapping the wedge firmly into the barrel before stressing.

The use of 'O' rings or circlips is important to ensure alignment of the segments, and they should be regularly checked and changed.

Advantages of open wedges:

- Ease of cleaning and maintenance.
- The wedge can be inspected during use.
- Low component count.

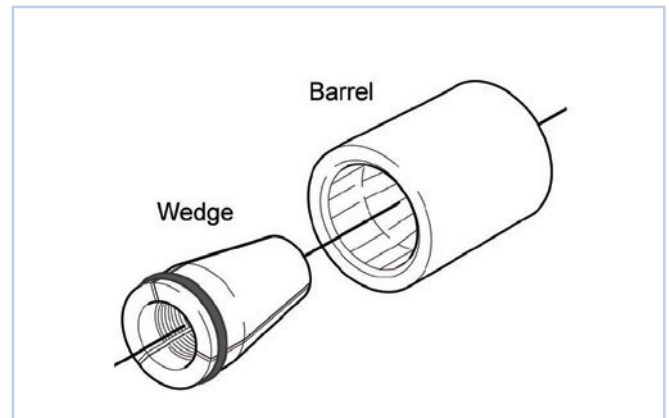


Figure 6.9
Open barrel and wedge.

6.4.2 Enclosed (spring-loaded) barrels and wedges

The spring-loaded grip is normally used at the non-stressing end of a bed, but when prestressing is carried out using a jack without power lock-off, they may be used with care at the stressing end of the bed. It should be noted that, when used in this way, the 'lock off' loss (where the wedge is pulled into the barrel resulting in some loss of prestress) may be high, particularly on shorter beds.

It is vital that the springs are in good condition to ensure the safe use of SLAs and DEJs. They should be changed regularly, especially when they are damaged by 'shock de-tensioning'.

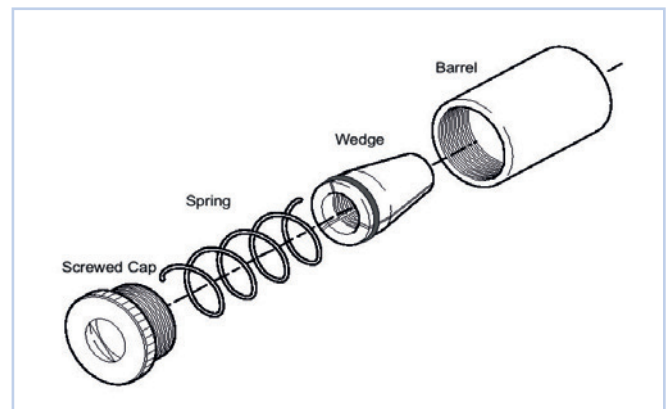


Figure 6.10
Enclosed barrel and wedge, the wedge cannot drop out.

6.4.3 Bayonet cap

Bayonet cap anchors feature a quick and easy release mechanism to facilitate inspection and cleaning of the wedges. They should normally be used at the non-stressing end of a bed. Bayonet grips can be used at the live end with a jack incorporating a lock off facility providing they have a press-in tube. This tube acts as a plunger within the grip itself.

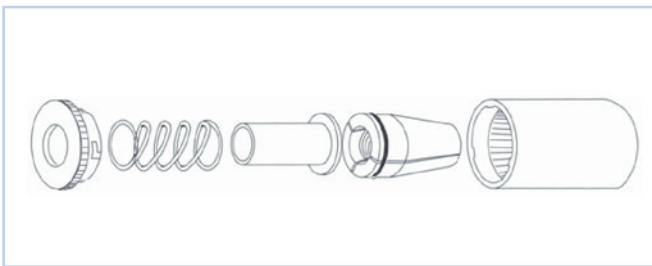


Figure 6.11
Bayonet cap, showing a press in tube, which allows use at live and dead ends.

6.4.4 Wire/strand coupler (also known as double ended joiner or DEJ)

Wire/strand couplers are available to connect two lengths of wire/strand. This enables reductions in wastage, as the wire/strand may be re-used when the prestressing bed is only partially filled. The large hexagon or knurled centre plug promotes easy assembly.

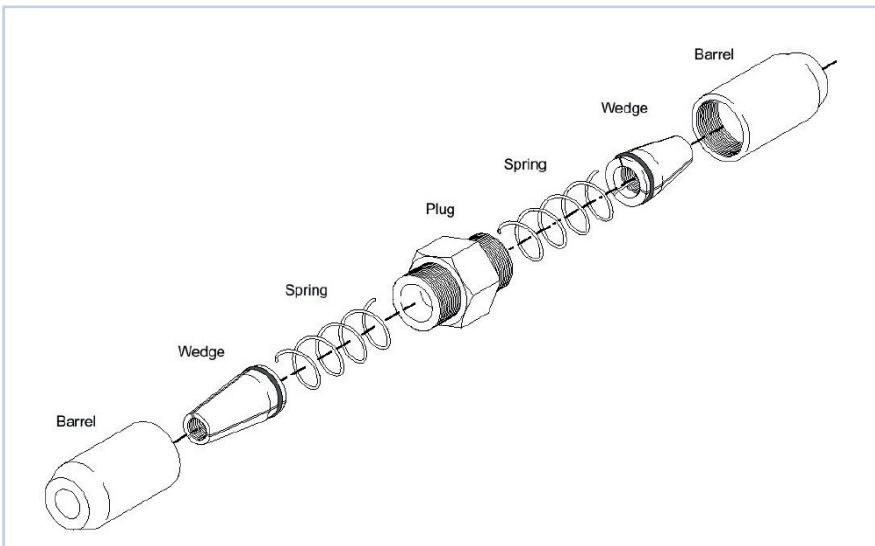
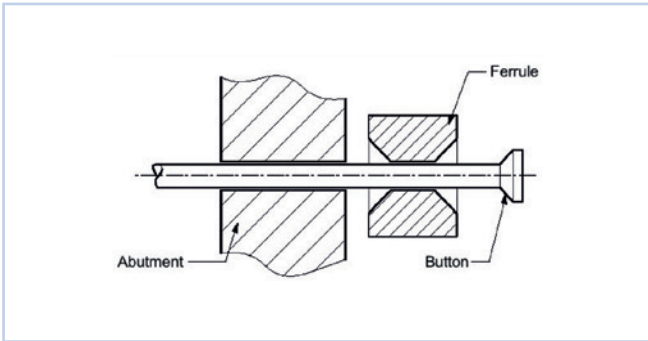


Figure 6.12
A wire/strand coupler.

Note: This type of anchor should be used with care as the end of the strand is enclosed in the wedge. As a result, it is difficult to ensure that the strand has been fully inserted and it is hard to monitor any slip of the strand in the anchor. A formal safe working system should ensure that the strand is marked so that when it has been fully inserted a mark is visible and will confirm that the anchor is performing correctly. Slippage of up to 4mm on the first pull is acceptable; any more slippage should be investigated and improvements made before the second pull is performed.



6.4.5 Button headings

Button headings can be used instead of barrels and wedges on wire systems. Used mainly in multi-stressing applications, the wires are cut to a precise length and a hardened steel ferrule is positioned as shown in Figure 6.13 prior to forming a button head on each end of the wire.

Figure 6.13
Button heading.

Button heads - are created using a crimping machine with each button being checked for defects by the operative when formed.

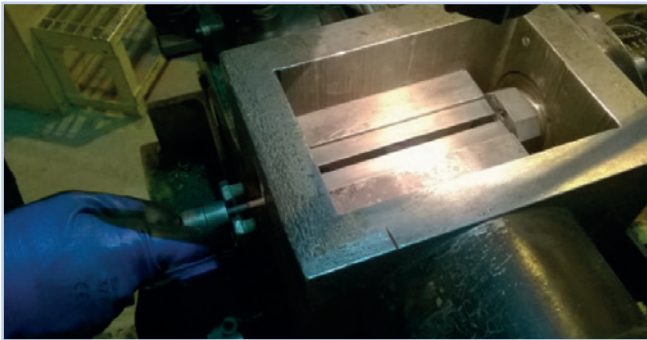


Figure 6.14
Button heading being formed.

Wire destruction test - is completed by a set length of wire being taken from the start of each coil and tested. This is completed by placing a ferrule and forming a button head on each end of the wire. The wire is then pulled using a test rig which applies a tensile force to the wire. The wire must not fail before the target force is reached in order to pass the test. Formal records of the wire batch number and the test result must be maintained.



Figure 6.15
Button head destruction test.

Wire length checks - a regular, normally daily wire length check is completed to ensure that the correct wire length is being produced, documentation to support the procedure used and the length check results needs to be maintained.

Storage of completed coils - it is important that all completed coils are wound tight and safely secured to reduce the risk of wires being damaged during storage and/or when being moved around the facility. Coils should be stored safely and supported to prevent coils rolling and causing injury to employees. Please refer to HSG 246 Safety in the storage and handling of steel and other metal stock.



Wiring up the beds - wires are pulled by a bed cleaner, or similar device, moving along the bed. The reel containing the wires is positioned to allow the anchor plate to be fitted to the pulling device/bed cleaner. The end plate is secured at the live end and lifting chains are re-attached to the dead-end anchor plates. An operative should travel down the bed watching the wire as it is payed out, with an effective warning system to stop running out if the wires become twisted. When the wires have been run out the securing plates, etc. are fitted to the dead and live ends in preparation for stressing.

Figure 6.16
Example of completed coil ready to be moved to the bed.

6.5 Fitting the barrels and wedges

When fitting the grips to the stressing wires/strand there are important factors to be considered:

- Is it the correct grip for the application?
- Is the grip the correct size for the wire/strand?
- Is it clean and correctly lubricated?
- Are the teeth in good condition?
- Is the 'O' ring serviceable?
- Is the spring full length?
- Has the grip been correctly locked off?

Failure to consider these factors could result in a grip failure.

Figure 6.17 shows a tube used to knock home the wedge within the barrel. The use of a tube can also prevent hand stab injuries from contact with the ends of wires and strands when fitting grips.

Wedges and barrels at the non-stressing end must be seated correctly with the wire/strand projecting at least 100mm and/or a predetermined distance to suit the location's method of grip and guarding. This needs to ensure that the wires are fully enclosed. Justification for the amount of wire/strand projection and the guarding standard used needs to be recorded on the relevant risk assessment.

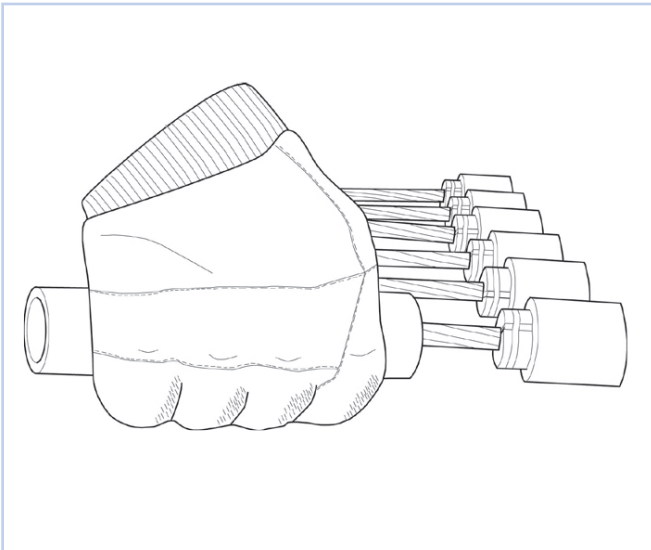


Figure 6.17
Fitting barrel and wedge.

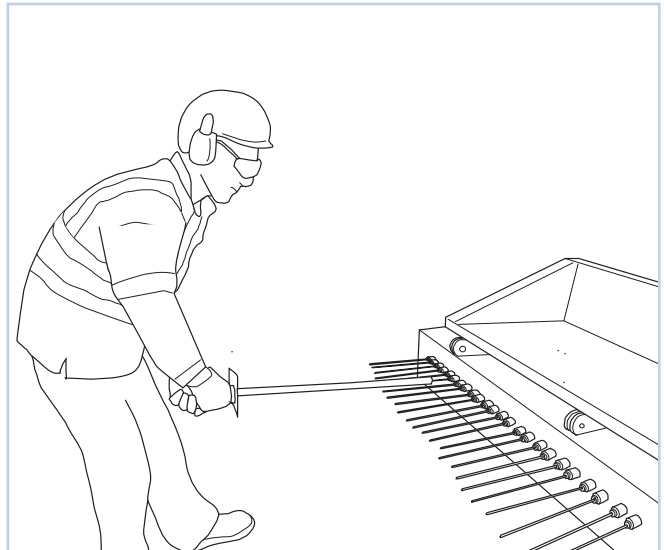


Figure 6.18
Wire/strand projecting by a minimum of 100 mm.

7 Stressing

7.1 Methods of stressing

Wires/strands can be extended either singly or by pulling all the wires/strands together (multi-stressing). When setting up a production site, consideration should be given to the method of stressing that will take place and whether single or multi-stressing is appropriate for manufacture of the product.

If any areas of concern/noncompliance are identified during the completion of the formal prestressing checklist (see Section 1.6) then stressing must not be progressed until improvements are made and all safety controls are fully implemented.

7.1.1 Single wire/strand stressing

A stressing jack is used to stress a single wire/strand at a time. It is the choice of the manufacturer whether to tension the wire/strand in a single pull or by multiple pulls depending on the length of the stressing bed, and to choose the length of the stressing jack accordingly. The degree of tension applied to each wire/strand must be pre-determined by a competent person.

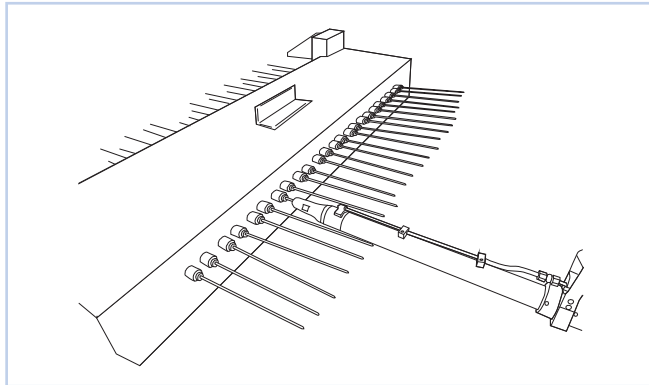


Figure 7.1
Stressing a single wire/strand
with a jack.

It is important to include manual handling of the stressing equipment within the risk assessments with particular regard to its weight and manoeuvrability.

It is also important to acknowledge that taking most of the weight of the jack from the operatives can also help prevent damage to barrels with a smoother or more gentle action when inserting the jack over the wire to be stressed.



Figure 7.2
Jack supported off overhead
balance linked to mobile unit.

Each wire/strand is stressed to the required load using a pressure measurement device on the pump or a load cell in the jack, calibrated to the actual load in the wire/strand. It is safety critical that the wire/strand is not overstressed and the pump must be fitted with a pressure relief valve to ensure that this does not occur. There are both keyed and un-keyed stressing jacks available. An un-keyed stressing jack will give a longer extension reading due to turning of the strand during loading. Periodic checking of the applied load should be carried out by a suitable method, e.g., deflection test, tension meter.

The setting of the pressure relief valve should be checked and set for each wire/strand configuration. Single strand stressing requires a safe system of work to ensure that there is no dependency on the high-pressure system relief valve.

Single wire/strand stressing requires a high degree of care in determining safe systems of work as a failure at the dead end can result in the wire/strand being pushed violently through the jack. Process and equipment should be provided to protect the stressing operatives during stressing, e.g., large end guards, as well as excluding others who may be working beside the bed containing the stressed strands/cables (see Section 6.4). Personnel not directly involved in the stressing operation must be excluded from the work area. Suitable notices and instructions need to be posted to help keep all persons away from the stressing operatives while completing stressing operations.

At no time should the operative stand in line with a jack or stressed strand/wire during or after stressing, as unplanned release of the stressed strand/wire can lead to serious injury or fatality.

A significant risk exists during the period of stressing and elongation of the wire/strand, so at this time the greatest exclusion zone should be considered. This requires that personnel in the area are restricted to a minimum.

Stressing ideally should be completed by working from one side, ensuring the stressing operative does not stand behind a stressed wire. If due to the bed design stressing needs to start from the middle of the bed and working outwards two operatives may be required, with each working from a point of safety and never positioned behind a stressed wire/strand. Stressing of wires/strands to a prescribed order for the designed pattern is desirable. The pattern needs to be included during the risk assessment process with improvements planned, where required, to make alterations to enable stressing across from one side, eliminating the possibility of standing behind stressed wires/strand.

Precautions after completion of stressing. Once stressing is completed, exclusion barriers are placed close around both ends to prevent all operatives accessing the area behind the anchorages. The stressing exclusion zone is only then reduced, but includes as a minimum that area immediately behind the wires/strands of both the dead and live ends. Exclusion barriers can also act as end guards if so designed.

End guards should be fitted with timber or other material capable of absorbing the energy from wires/strands (see Section 7.4). Once they are stressed, guards should be lowered over the ends of the wires/strands to fully enclose them.

7.1.2 Multi-wire/strand stressing

This system is employed in high volume production and allows for all wires/strands to be tensioned at the same time. The abutment at the end of the bed is 'live' and moves under the direction of a single or multiple hydraulic cylinder(s) to a predetermined extension. Operatives can then fit locking collars/chocks and guards into position and casting can commence. It is safety critical that the wire/strand is not overstressed and the pump must be fitted with a pressure relief valve to ensure this. Periodic checking of the applied load should be carried out by a suitable method, e.g., deflection test, tension meter.

Controls to operate the multi-stressing process are generally completed from a control panel away from the stressing head and/or from behind a guarded location. Consideration should be given to the introduction of a remote facility to help ensure that the stressing operative is an extended distance away from the live stressing operation.



Figure 7.3
Multi-stressing mould in tensioned position.



Figure 7.4
Multi-stressing remote control, allowing a greater distance from stressing operations.

7.2 Placing safety restraints

When released, the stored energy in a stressed wire or strand could cause severe injuries and in some instances these can be fatal; therefore it is crucial to restrain them adequately. Once a wire/strand is shock released it will initially travel along the same axis as that in which it was stressed. The direction will change once it makes contact with the stressing bed or other structures and can be extremely unpredictable. It must also be realised that this movement of the wire/strand will occur in milliseconds and therefore a person will be unable to avoid it.

In order to minimise the movement of the wire/strand when failure occurs and the tension is released, the stressing bed must be fitted with restraints at roughly equal centres along its length. The entire length should be considered from dead end anchor to live end anchor. This is particularly important on open beds used for long-line machine casting when there is no restraint from stop ends, cages and deflector plates.



Figure 7.5
Wire restraint secured over hollow core flooring bed.

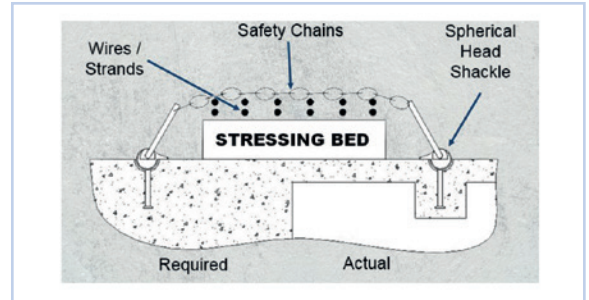


Figure 7.6
Section through casting bed showing safety chains securing pin foundation requirements.



Figure 7.7 - 7.11
Selection of safety chain, clamped pin (red, top right) and clamped stop ends (bottom right) style wire restraints.



Figure 7.12
Restraint bar placed over T-beam casting bed.

Restraints can include chains, straps, bars, fabricated clips and bulk heads. The restraints spacings should be determined during the manufacturer's risk assessment process, but generally between 5 – 10 meters apart. All restraints, including the securing points, either to the stressing beds / structure or held in place by encapsulating all stressed wires / strand, must be able to withstand the forces generated by a release of one wire/strand to avoid failure and maximise containment.

Due to the unpredictability of a failed wire, the local risk assessments need to record all controls and justification for the chosen restraint type and spacing, taking into consideration the mould/bed design and other control measures implemented during the stressing process, which include: -

- Stressing to max 75% of SWL of wire or strand
- Clear the factory / shop of all personnel. Stressing operator to be behind suitable guards
- Verbal and audible warnings
- Supervision formal checks all controls in place before stressing completed
- Stressing completed in 2 stages, initial pull approx. 25% of designed product stress level to confirm all wires/strand and grips are in good order before stressing to full designed level.
- Mandatory re-entry time period to allow stressed wires to settle (approximately 2 mins)
- Specific stressing operator training as part of the CoP requirements. All operatives need to attend the session which includes the need to comply with the standard controls listed above, along with any local controls.
- To help reduce the chance of wire or strand failure the standards imposed on the wire manufactures to BS 5896, batch / coil test certification provided, transport arrangements, storages when at the factory, along with handling from wire store through to the beds are all completed in line with CoP to prevent deformation or damage of the wire which could lead to a failure.
- External annual monitoring of compliance to the CoP requirements includes all the points above with performance communicated to the individual companies and tabled for discussion at the MPA H&S steering committee. Completion of previous audits is also reported and discussed, with a lower score achieved if actions items have not been completed between audits.

The stressing operative should carry out a daily visual inspection of all safety restraints and securing points together with the operation of visual and audible warnings.

Unpredictable ricochet or rebound is possible during an uncontrolled release and consideration should be given to deflections of wire/strand caused by objects around the stressing line, for example walls, ceilings and equipment. This may affect how many restraints are required during the stressing process and where they are positioned. It will also affect the design and positioning of the guards.

The use of hardwood timber (or other absorbent material) as a lining for guards, barriers and sometimes abutments is recommended. The wire/strand is more likely to embed into timber rather than ricochet, so timber increases the chance of containment during an uncontrolled release. The effectiveness of the timber will increase as its thickness increases. Where guards totally enclose the stressed wires absorbent material may not be required. Justification for not fitting absorbent material needs to be recorded on the relevant risk assessment.

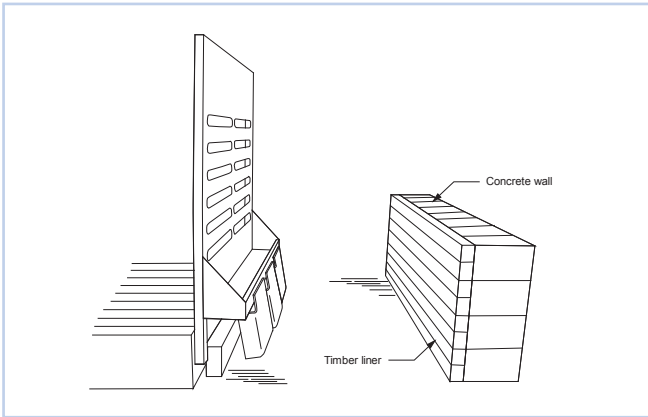


Figure 7.13
Guard at end of stressing mould with absorbent timber facing.

Any restraints should remain in place throughout the production process until casting occurs, only being removed when the process dictates, e.g., a casting machine travelling along the stressing line. Where possible, machines travelling over exposed wire/strand should be kept to a minimum. Operatives should always be aware of other equipment that may now be in place such as stop ends and fixed wire/strand pattern plates that may also act as a form of restraint depending on their design.

7.3 Stressing load checks

For single wire/strand stressing, the load in a wire/strand is set by the correct calibrated pump and jack.

For multi-stressing the bed can be calibrated in a similar manner by installing a load cell between the anchor and the abutment for a chosen strand/wire and the load recorded against the extension.

For both techniques independent checks on the load can be carried out after stressing is complete. Two types of meter are available for this function.

1. Voigt Meter. This equipment indicates the load in the strand/wire as it is deflected between two fixed points. By deflecting the strand/wire a given distance from the load restraint a direct read out is available of the tensile load.
2. Digiforce meter. This measures the frequency with which a wire/strand vibrates when struck. The frequency, which is a function of the tensile stress in the wire/strand and the distance between restraints, is measured by a hand-held calibrated meter that provides a read-out in decanewtons.

7.4 Guarding

Guarding is required to ensure protection of the stressing operative during stressing, all personnel after stressing is complete and those involved in the de-stressing process. Fixed guarding (close fitting, tool tight, of adequate strength and design to withstand the forces exerted during an uncontrolled release) and distance guards (barriers and guarding at a distance from the hazard where injury cannot occur) or a combination of both fixed and distance guards can be used as well as cages and/or pits for the stressing operatives.

Fixed close guards to the 'Live and dead' ends of pre-stressing equipment are constructed from steel of adequate strength. It is recommended that impact areas of guards should be constructed from minimum 3mm S275 grade structural steel. Local risk assessment will include justification for guard design and strength, along with improvement plans, including time scales, where improvement needs to be made.

The grade and thickness of steel used for other guards and stop end design on different pre-stressing equipment, needs to be decided, again through local risk assessments, taking advice from suitable qualified engineering support. Evidence of chosen steel standard needs to be held and available for review and audit.

The risk assessment process must ensure that all failure modes are considered together with the protection methods/controls to prevent harm if a failure occurs, including the extent of the exclusion zone. Consideration should be given to the angle of the stressed wires and whether the guard is robust enough to constrain a wire in the event of unplanned release.

Those areas that are considered to be hazardous zones during stressing should be identified and communicated to all personnel who work either in or are likely to enter a prestressing factory. Only those who are trained, authorised and essential to the stressing process should be involved in the prestressing process, with all other persons being excluded from the hazardous zones. A physical barrier needs to be in place during the stressing process to help prevent unauthorised access to the danger zones, as identified during the risk assessment process. Some or all of these zones may remain hazardous to varying degrees until de-stressing takes place; guarding and work procedures should reflect this. At no time should a person be permitted to be directly in line with an unguarded stressed wire/strand.

Consideration also needs to be given to the possibility of a failed wire flailing backwards and around the end guards, with a risk of injury to those behind the stressing operations being struck. A combination of guarding, distance and the extent of exclusion within the restricted zone should be considered and included in the risk assessment process.

A hierarchy of guarding should be applied, e.g., a cage for the stressing operative, then a bed guard, including an increased exclusion period following completion of stressing of the last wire.



Figure 7.14
Examples of a stressing operative cage and extra abutment guarding.

Various examples of guard design in operation are shown below; some totally enclose the wires, some partially enclose the wires with absorbent material to prevent wires from ricocheting, one is a button head close proximity guard and the last deflects wires into a pit.



Figure 7.15
Stressing end of a wet-cast T-beam. Left: Guard raised showing timber insert used to absorb impact. Right: Guard lowered to contain all prestressed wires/strands.



Figure 7.16
Left: Enclosed dead-end hollowcore. Right: Button head end guard.



Figure 7.17
Left: Drop down live end guard with wooden insert. Right: Upright stressor guard.

Interlocking guards with key trap systems should be considered for new equipment purchases and during end guard modification and improvement. This type of guard is generally only possible with multi-stressing systems where access to individual wires is not required. However, if it can be developed to suit single stressing operations this should be encouraged.



Figure 7.18
Interlocking end guards, preventing stressing until guards are lowered and fixed.



To reinforce the recognition of the danger area at the live and dead ends the addition of floor demarcation should be considered during the risk assessment process.

Figure 7.19
Highlighted danger area at the end of the beds.



Figure 7.20
Sliding guard covering stressed wires.



Figure 7.21
Sliding cover used to enclose stressed wires.

For single wire stressing, which involves working across the wires, it is good practice to cover the stressed wires as stressing progresses. This can be completed by pulling a movable guard across the stressed wires. This guard must have absorbent material on the wire-facing side to prevent ricochet if failure occurs (Figure 7.20). Other examples include a sliding cover which gives access for the jack to complete stressing. As stressing progresses the cover is slid across guarding the stressed wire. The covers can be locked shut when stressing is completed helping to ensure that access is not possible until wires have been de-stressed.

After stressing is complete the anchors at both ends should be checked to ensure that no slip has occurred and all guards are in place before the bed operatives are allowed back into the hazardous area. As previously mentioned, all guards should be in place prior to stressing if possible. To avoid lifting guards to check for slippage after stressing has been completed a paint line, across all strands/ wires, can be applied close to the abutment before stressing, enabling easy identification if a slippage has occurred.

Once stressed, working on and/or in close proximity to the stressed beds should be avoided/kept to a minimum. The local risk assessment should detail the specific production reasons for working on or close to the stressed beds following the initial stressing through to covering the cast beds. These include: -

- Putting in stop ends
- Attaching lifting clips
- Quality checking of wire and strand tension
- Casting concrete
- Covering the beds with covers following casting
- Generally working around the beds to prepare wire/strand for the next day and housekeeping (no access should be permitted on the beds) when cast and covered.

The main aim of the regular risk assessment reviews is to try to eliminate or reduce access requirements, by production changes, planning the design for new beds, introduction of new stressing innovation etc.

Walking on the stressed bed to get from one side to the other should be avoided or suitable control measures should be in place to provide safe access if crossing cannot be avoided, e.g., walkway bridge, access fabricated to the front of the casting machine, etc.. The controls should be determined during the location's risk assessment process.

The hazardous zones should be delineated by consideration of the likely movement of the wire/strand should an uncontrolled release occur and the zones should be clearly identified. The zones will also be dictated by the type of stressing system, the restraint used during stressing and the type of guards used as part of the stressing operation. Exclusion zone establishment and the controls implemented to control compliance with the exclusion need to be developed and documented during the location's risk assessment process.

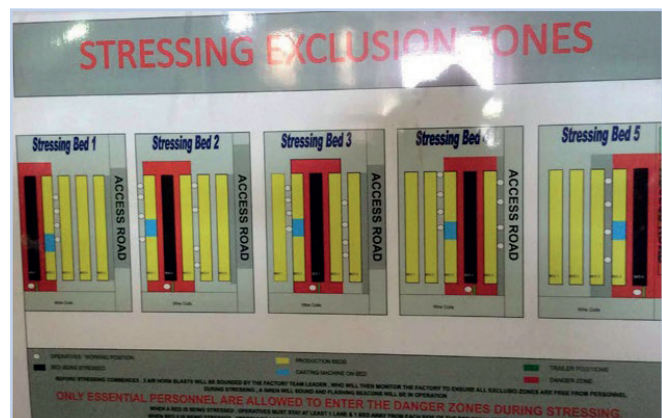


Figure 7.22
Example of stressing exclusion zones.

7.5 Warning systems

To ensure that operating personnel and visitors are aware when stressing is taking place suitable warning systems should be installed; these should include lights, sirens and notices.

7.5.1 Lights

A flashing light system should be installed that is visible from both ends of the bed to indicate that stressing is in progress. Depending on the layout of the manufacturing unit, warning lights outside of the stressing area should be considered for advance warning. This is especially important on the outside of doors which lead directly to the manufacturing unit.

When single stressing with mobile units it is good practice to add a flashing light to the units to indicate clearly when a unit is in use (Figure 7.23).

7.5.2 Sirens

The use of an audible warning is expected to support and complement a visual system. The warning must be loud enough to be heard when close to the manufacturing area/danger zone, but not a source of frustration and reduced communication from those directly involved in the stressing operation. The alarm should sound continuously during the stressing process with sounders positioned at the entrance points where stressing is being completed. The audible warning should start before stressing commences (approximately 1-2 minutes) and should be stopped at a safe time after stressing operations (approximately 2 minutes), to allow the stressed wires and strand to settle, before all clear to re-enter the manufacturing unit can be confirmed.

7.5.3 Notices

Warning notices are recommended at all access points indicating that stressing is hazardous and that access is restricted when the lights or sirens are in operation.



Figure 7.23
Flashing light on mobile stressing unit.



Figures 7.24 - 7.26
Examples of warning notices.

7.6 Safe Interventions – What to do if things go wrong

By following the requirements and practices detailed within this Code, it is expected that prestressed concrete products will be produced incident/accident free and in a controlled environment. However, when unexpected instances occur there needs to be a documented procedure to deal with them in a controlled and safe manner.

The process developed needs to be recorded within the location's risk assessment process together with a specific procedure to support the planned actions to be undertaken by the stressing operatives, supervisors and external support as required. The risk assessment (see Section 1.3) needs to include reference to all the possible failure modes together with the controls which are in place to prevent such instances. However, if a failure occurs the extent of the failure and the process/SSOW to deal with the instance needs to be developed with all relevant persons involved and confirming the process to follow in a failure event. This will help ensure that all such instances are managed in the safest way possible and in a planned and controlled manner.

To support the production of SSOWs, all failure modes linked to specific operations need to be recorded during the risk assessment process with agreed controls included to support the safe interventions when a failure occurs.

Possible failure modes which could occur, mainly during or very shortly after stressing, include:

- Failed strand/wire;
- Failed button head;
- Slipping/slipped barrel and wedge;
- Crossed wire/strand, and
- Mechanical failure of stressing equipment (single and multi-stressing).

7.6.1 Failed strand/wire – single stressing

■ T-beam/lintel

Live end guards should remain in place while the initial investigation is completed, including agreement on the actions to be taken to rectify the failure. The failed section should be removed/cut out as far as possible. If safe to do so, the wire/strand should be replaced, the B&W refitted and the stressing process recommenced from a position of safety and out of the line of fire.

If the safe replacement of wire/strand is not possible, then live end guards should be fitted while the failed wire/strand is removed. Dead-end guards should remain in position while the failed section is removed/cut out as far as possible. Finally, one should progress with stressing operations as required and cast the bed, marking the channel where the failure occurred so that product can be scrapped when cured and removed.

■ Hollowcore/panels

Live end guards should be fitted while the failed wire/strand is reviewed. Dead-end guards should remain in position. If the failed section is not critical to the design requirements, then wire/strand should be removed/cut out from the casting area. Finally, one should progress the stressing operation and ensure that persons involved maintain a position out of the line of fire.

If the failed section is critical to the final product design requirements and needs to be replaced, then the end guards should be kept in position while the failed wire/strand is reviewed. The failed wire/strand should be removed/cut out from the casting area.

The sections enclosed by the end guards should remain in position until the new section has been laid on the bed, fed through the safety chain/retention system and is ready to be passed through the foot plate.

It is critical that access to the part-stressed bed is completed from the non-stressed side, ensuring that no direct access is possible to the stressed lines.

When removing the failed section and B&W and making the final connection and fitting the B&W to the new wire/strand, the guards need to be lifted. This can only be completed with great care. In order to ensure that no persons are in the line of fire, extra guards may need to be introduced to protect all works, if identified during the risk assessment process. Once completed the dead-end guards should be closed and secured. Stressing can then recommence in line with the standard SSOW, whilst ensuring that the stressing sequence implemented prevents the stressing operatives being in the line of fire.

■ Multi-stressing/button heading

All live and dead-end guards should remain in position and the bed de-stressed in line with the standard SSOW for de-stressing. Once the bed is fully destressed the failed section should be removed. New wire/strand should be fitted and stressing recommenced in line with normal operations.

7.6.2 Slipped/failed barrel and wedge

■ Single Stressing

Live end guards should be fitted while the initial investigation for the B&W failure is completed, including agreement on the actions to be taken to rectify the failure. It is necessary to confirm that the wire/strand linked to the B&W failure is no longer under tension. The guards covering the B&W should then be lifted and the B&W removed and stored for further investigation. This must be completed from a safe position out of the line of fire of stressed wires. This may also be achieved by being positioned behind additional guards, in line with the location specific SSOW requirements.

It is necessary to confirm that the wire/strand is not damaged before fitting new B&Ws. If there are any signs of damage, then the wire/strand will need to be replaced. Once the B&W has been refitted, the stressing process should be progressed in line with the normal procedure. All persons involved must maintain a position out of the line of fire.

■ Multi-stressing

All live and dead-end guards should remain in position and the bed be de-stressed following the SSOW. The guards covering the B&W should then be lifted and the B&W removed and stored for further investigation.

It is necessary to confirm that the wire/strand is not damaged as a result of the slippage before fitting new B&Ws. If there are any signs of damage to the wire/strand, then this will need to be replaced. Once the B&W has been refitted the stressing process should be progressed in line with the normal procedure.

7.6.3 Crossed wire/strand

As stressing progresses if it is observed that two (or more) strands/wires cross, then stressing shall be halted and the extent of the crossing established. For multi-stressing operations the tension should be taken off and when fully removed, the wires should be re-positioned. Stressing should recommence when it is confirmed that no wires are crossed.

For single stressing operations, once the extent of the crossing has been established it must be decided if a controlled release of the affected wires should be completed, or if the stressing jack should be fitted with a de-tensioning nose and the affected strand/wire de-tensioned and repositioned.

Both of these operations have concerns and consideration must be given to the points below:

■ Controlled release

The Operative will need to be close to the wire/strand during the release/cutting process. The method of cutting the strand/wire must be accurate and controlled to ensure that only the affected lines are released. Live and dead-end guards must remain in position during the release, with guards lifted while the strand/wire is replaced following release. Lifting the guards will expose live strand/wire. Additional guards will need to be introduced during the replacement, keeping persons out of the line of fire.

■ Use of de-tensioning nose

Live and dead end guards will need to be lifted/removed with the operative close to the line of fire when accessing the affected line's B&W. Direct contact with the jack nose area will be required to complete de-tensioning and tension cannot be fully released, thus leaving a problem to release the remaining tension.

Note: The stressing jack de-tensioning operation should only be completed by very experienced stressing operatives, who have had specific training and physical instruction (from the manufacturer) to operate the de-tensioning nose, emphasising the increased hazards and controls that are required during the process.

Controlled release of the strand/wire may be the preferred method. However, this must be decided and documented on the locations risk assessment process. A SSOW must be developed to support the safest method to perform a controlled release.

7.6.4 Mechanical failure of stressing equipment (single and multi-stressing)

needs to be an agreed and documented process to follow to ensure that repairs and alterations are made to reduce the possibility of an uncontrolled release of stressed wires/strands or a part-stressed bed being left for an extended period of time.

A SSOW needs to be in place detailing the process to follow. The SSOW must support the controls listed on a specific risk assessment.

Depending on the stressing equipment used, the following practices must be followed in the event of a failure:

■ 7.6.4.1 Single stressing system failure process

- The failure should be reported to the location's supervisor/manager and exclusions zones, guarding and all alarm systems should be kept in place. Consideration should be given to the addition of sentries to keep persons away from the part-stressed bed.
- The reason for the stressing system failure should be reviewed.
- The actions recorded in the mechanical failure SSOW should be completed, making repairs to the stressing system as required.
- The repairs to the stressing pump and jack must be completed from a safe location and ideally away from the part-stressed bed, outside the stressing exclusion zone.
- Once the repairs have been completed the stressing operations should be progressed in line with the standard stressing SSOW.

Note: It is necessary to ensure that all spare components that may be required, e.g., jack components, 'O' rings, hydraulic hoses etc., are stored on site so as to enable a quick and effective repair. Repairs must be made by suitably trained persons.

7.6.4.2 Multi-stressing system failure process

- The failure should be reported to the location's supervisor manager and exclusions zones, guarding and all alarm systems should be kept in place. Consideration should be given to the addition of sentries to keep persons away from the part-stressed bed.
- The reason for the stressing system failure should be reviewed.
- The actions recorded in the mechanical failure SSOW should be completed.
- If repairs can be made from a position of safety, in line with the SSOW, then the repairs should be completed and subsequently the stressing operation progressed.
- If repairs cannot be made without an increased safety risk, or with the stressing rams/head under tension, it is vital that the bed is made safe by completing a controlled shock de-tensioning. An experienced operative will need to be positioned close to the live end abutment with the wire strand being cut and released away from the operative. Exclusion zones, guards and safety systems should remain in place until all stressed wires/strands have been released and the bed is fully de-stressed. The method of cutting the strand/wire must be accurate and controlled.
- When the bed has been fully de-stressed suitable repairs should be completed and improvements should be introduced to the system to prevent a recurrence, wherever possible.

Multi-stressing systems need to be designed to limit conditions which increase the possibility of potential failures, these include:

- Hydraulic system linking the rams, equalising pressure, to avoid off center stressing between the two rams. Reducing the chance of an unequal pull and potential ram/stressing abutment locking.
- The stressing system designed to eliminate catastrophic failure. Check valves should be incorporated, so that in the event of a failure the rams remain in the position if a failure occurred. However, the part-stressed bed should not be held on the check valves for an extended period of time.

The completion of thorough and detailed bed inspections, as detailed in Section 3.4.3, should help to identify possible defects which could result in a failure.

7.6.5 General conditions/controls to be implemented

- Safety chain/retention systems should not be removed if any of the wires/strands are stressed.
- Failed wire/strand and B&Ws should be removed as far as possible, keeping the guards in place. It will be necessary to check with the location's design/structural team what the impact of the missing wire/strand will be on the structural performance of the finished product.
- For single re-stressing, it will be necessary to include extra guarding to keep the stressing operative out of the line of fire from the stressed wires, during the re-stressing operations.
- SSOWs should be generated and agreed for dealing with specific failures so that there are no failure modes which have not been considered and for which no controls have been introduced.
- For all instances of failed wire/strand and slipped B&W, both ends of the failed section and/or the B&W should be retained for independent investigation.
- Following a failure, all guards should remain in position during the initial investigation until a documented SSOW has been agreed to rectify the failure.
- If the failed wire/strand is not critical for the product design requirements, then one should consider removal of the failed ends for further investigation. One should cut back the section to ensure that it cannot interfere with the casting process and then cast the bed.
- If repeat failures occur, then stressing operations must cease. Beds must be de-stressed and left in a safe condition. A full investigation must take place to establish the reasons for the failures and improvements must be introduced to prevent reoccurrence.

Note: De-stressing and re-stressing of the wire/strand can be completed on numerous occasions as long as the wire/strand has not gone beyond its elastic limit. It is common that the applied extension/stress corresponds to a strain between 60% and 80% of the elastic limit of the wire/strand. This will need to be confirmed by the local design team and steel manufacturers, with suitable confirmation of local arrangements added to design details and the SSOW for stressing operations.

7.6.6 Failure Investigation

It is essential that a thorough and detailed investigation for any failure is completed (see Section 1.9). This must involve all relevant persons, including specialists, as required. For all failures, especially broken wires/strands and catastrophic failures involving B&Ws, the failed components must be independently investigated to establish the reason(s) for failure, e.g., manufacturing defect, handling damage etc. Outcomes which could have safety implications for the prestressing industry should be communicated as appropriate.

8 Concrete casting

There are several methods of casting prestressed elements, they basically fall into two categories, based on concrete workability. Every manufacturing operation will be different and must be risk assessed in full. Some considerations are discussed below.

During any type of casting it is important to remember to use restraints on the wire/strand for as long as possible and not to overload or damage the wire/strand by putting machines or heavy equipment directly onto them. The design of the restraints and style of machines/equipment placed on the stressed beds need to be decided with due regard for potential safety implications. The thought process needs to be detailed within each specific location's risk assessments.

8.1 Machine casting

Machine casting includes extrusion/slip form casting. Products, such as hollowcore flooring, require the creation of various shapes in the product immediately after forming. These could include open cores, shaped ends, and holes and notches; in all cases particular care has to be taken to ensure that the wires/strands are not damaged during the process as they will still be in a fully stressed state. Marking out of the desired lengths and shapes will also take place at this stage.

Some processes involve the removal of concrete at an early stage, when the concrete is still in the 'green' state. This process is completed using soft tools and concrete suction devices to ensure that the stressed wire/strand cannot be damaged with the potential for failure. This process also reduces the level of manual work to cut cured concrete together with the associated health concerns of noise, vibration and dust when cutting cured precast concrete products.

8.2 Wet casting



Figure 8.2
Wet casting T-beams.

In a wet cast process the concrete mix is designed to flow around the stressing wires/strands that are placed within a specially shaped mould that forms the final shape of the element. Compaction can be assisted with external vibration that could include clamp-on vibrators, beam vibrators or vibrating pokers. Extreme care should be taken with pokers so as not to damage the wires/strands. Consideration should also be given to the possibility of hand arm vibration.

Constant vibration can seriously reduce the life expectancy of a mould and checks should be completed on a regular basis to ensure that it is not showing signs of cracks, twisting or opening of seams (see Section 3.3). All damage should be repaired as soon as possible.

Self-compacting concrete can be used in many situations; this removes much of the risks and damage caused by the various forms of vibration and can also increase the life expectancy of the mould.

8.3 Concrete strength

Concrete strength should be checked before de-stressing and to check that the design strength has been achieved.

- Cubes cured on the bed for transfer (i.e., minimum strength for de-stressing) and in temperature-controlled rooms for 28-day design strengths
- By the Maturity Method, which analyses the time and temperature profile of concrete to allow correlation figures to be established with the strength of concrete.

The time required for the concrete to achieve its required strength must be determined by a competent person. De-stressing **must not** be undertaken until such time as the concrete has achieved sufficient maturity to prevent loss of tension, with the competent person confirming it is safe to de-tension.

8.4 Casting equipment / Bogies

During bed preparation, casting, de-stressing, cutting and removal of products, a number of types of equipment run on rails positioned on both sides of each bed. Depending on the controls implemented, equipment movement and the proximity of other beds, the hazards of entrapment and shearing may be present, especially when pieces of equipment pass each other. It is essential that during the risk assessment process, and ideally at the design stage, these hazards are eliminated. Where this is not possible, controls need to be implemented to reduce entrapment and shear hazards to a minimum. Evidence of the controls implemented needs to be recorded on the location's risk assessment record.

During the risk assessment process, the need to include controls to prevent operatives from falling whilst riding on equipment should be added. This needs to include railings and controls to limit access and egress to the equipment whilst moving.

9 De-stressing

The term de-stressing refers to the removal of tension in the wire/strand and occurs once the transfer strength of the concrete has been achieved. De-stressing may also be necessary prior to casting, due, for example, to crossed wires/strands that can occur during setting up of the beds. The de-stressing operation can be a high-risk activity, whether the tension is released in a controlled manner (soft de-tensioning) or in an uncontrolled manner (shock de-stressing). Care is necessary and normal stressing precautions need to be taken. To help ensure that de-stressing is completed to the prescribed safe procedure a formal risk assessment and SSOW with appropriate safeguards, e.g., guards, need to be in place with all relevant staff trained and acknowledging the risk assessment and SSOW requirements.

The de-stressing of stressed wires/strands can require the loading to exceed the normal percentage of the guaranteed ultimate tensile strength (GUTS). This is due to higher loads being applied initially to remove the chocks or stops inserted during the stressing operation. This process needs to be controlled carefully with the maximum loads limited to those determined and specified by the design engineer.

Slip in the anchors, or in the product, after de-stressing can be monitored by marking a straight line across the wire/strand close to the abutment before stressing commences, at the dead end or at both ends. This is particularly valuable when multi-stressing or when the anchors are covered with guards and the ends of the strand or wire are not visible.

9.1 Multi-wire/strand de-stressing

The safest way to de-stress a multiple wire/strand stressing bed is by using special rams built in to the ends of the bed. These will allow multi-de-stressing to take place, eliminating both off-centre loadings and shock loads. The tension in the wire/strand is first increased slightly, just enough to allow removal of the locking collars/chocks. Once these are removed then the load is slowly released until the multi-stressing head is in a fully retracted position and no load remains on the free wire/strand.

9.2 Single wire/strand de-stressing

Single wire/strand de-stressing is potentially more hazardous and requires greater care to eliminate both off-centre loadings and shock loads. The load in the wire/strand can be released using either a special stressing jack nose or a bespoke tool; in both cases the supplier's instructions should be adhered to, following a set sequence detailed in a specific SSOW.

Shock de-stressing, where the wires/strands are cut with either a gas torch or disc cutter, should be carried out with care as in both cases the unrestrained ends of the wires/strands have a tendency to retract suddenly, and in the case of strands can splay out in an unpredictable way. Extreme care must be taken when cutting wires/strands; end guards must remain in position and operatives need to stand in a safe position (as detailed by the specific SSOW for the operation), where the retracting wires will not strike them upon release of the stored energy, in particular on a bed which is not fully cast.

9.3 Cutting Wire / Product after de-stressing

Once de-stressing has been completed some products will be cut and lifted by automated/semi-automated machinery. Other operations are completed with more manual based equipment and processes. Depending on the process used hazards to the operatives and those persons in the vicinity could include: noise, vibration, fumes, respirable crystalline silica (RCS), musculoskeletal disorders, etc..

During the risk assessment process look to include improvements reducing and ideally eliminating the hazards listed above and any others specific to the process being used. Monitoring of exposure levels will need to be completed, especially for noise levels, dust/RCS exposure and the effects of vibratory tools/equipment, together with introducing improvements to ensure that compliance with legal requirements is achieved as a minimum. Then improvements should be planned and completed to reduce exposure to the lowest levels possible where elimination is not possible.

10 Removing barrels and wedges

The removal of the barrels and wedges from the wires/strands after use is aided by the correct use of release agent. If removal by hand is found to be difficult it can be achieved using the hydraulic jacks. Once the tail ends of the wires/strands are removed from the stressing beds, re-application of the jacks to the grips will easily pull the wedges from the bores of the barrels.

Use of a hammer is **not** recommended as this can produce stress cracks in the fittings. Where there is insufficient wire/strand length to allow a jack to be used, special barrel release tools are available from the grip manufacturers.

This applies especially when joiners are being used as they will require total dismantling. Supplies of these specialist tools should be available at all times in order to reduce the risk of operatives resorting to incorrect methods of barrel and wedge removal.

Appendix introduction

The following appendices are intended to support compliance and ongoing improvement with the requirements of Section 1 of this Code of Practice covering the management of health and safety within the prestressing industry.

The examples below are intended to be referenced during health and safety system, risk assessment and safe systems of work reviews, to help ensure that all relevant requirements and details are included before, during and post stressing operations.

The appendix examples are not intended to be copied and used as they are (unless they are to be implemented and reviewed following a relatively short period and then made site specific). The intention is to provide a reference document/example of a format to use and to be included as part of company specific documents, suiting local conditions and industry expected requirements. As detailed in Section 1, this process should be completed with the involvement of all key personnel involved in stressing operations.

Appendix 1: Stressing policy

General Policy

The following is a useful guide for all companies involved with prestressing activities when developing a stressing policy that outlines the company commitment for safe stressing and the Code of Practice expectations.

The policy should state that when tensioned, wire and strand contain a considerable amount of stored energy, which in the event of any failure of a wire/strand, anchorage or jack, may be released violently.

The risk of injury can be high if suitable controls are not maintained. To prevent incidents, management and personnel are responsible for ensuring that the following policy and procedures are maintained. Health and safety leadership is a critical element in the prevention of incidents and in ensuring all controls are fully implemented. This appendix provides guidance on how to record and more importantly demonstrate leadership for safe stressing operations.

The policy document should identify relevant reference documents, for example:

- This MPA Precast Code of Practice for the safe stressing of prestressed concrete products
- Health & Safety at Work Act 1974
- BS 5896: 2012 - High tensile steel wire and strand for the prestressing of concrete. Specification
- Existing procedures and documentation.

Priority Policy Inclusions

The priority elements and details which need to be listed within the policy are referenced below:

- a. The policy needs to clearly describe the senior leadership team's commitment to comply with the Code's requirements for all stressing operations.
- b. The policy must commit to ensure that all elements of this Code are implemented and describe a clear improvement planning process to raise standards where required, especially through the risk assessment process.
- c. The policy must outline the need to reference this Code during the production of risk assessments and safe systems of work and as an aid to monitoring and reviews.
- d. The policy must record that the risk assessment process plus the implementation of suitable and sufficient control measures is the key to the management of health and safety during the stressing process. Risk assessments will detail the importance placed on the risk assessment process for stressing operations and general health and safety management. Assessment compliance will be monitored at the management meetings, especially the completion of improvements recorded on the assessments which will all be overseen and monitored by the senior leadership team.
- e. The policy will commit the organisation to support the organisation's current stressing management control and improvement practices.
- f. The policy will be reviewed by a competent person to determine if it remains suitable and sufficient on a maximum 12 monthly basis.
- g. The policy will commit to representing the business by attendance at relevant industry H&S meetings, together with communicating incidents and actions taken to improve standards. This will support the spreading of improvements and positive safety elements which could help all industry members raise safety standards.

General Company Policy Elements

The general requirements of the policy are linked to Section 1 of this Code related to the management of Health and safety during Stressing operations. These include but are not restricted to the elements listed below:

1. All factories must have risk assessments documented for all stressing activities.
2. All factories must have written production procedures that reflect their working routines.
3. Only specially trained and authorised personnel will be allowed to carry out stressing activities.
4. Stressing forces, extensions, calibration tolerances and load conditions must be documented by a chartered engineer.
5. Prestressing equipment must be suitable for purpose, regularly maintained and calibrated with appropriate records kept, and used in accordance with the manufacturer's instructions.
6. Procedures for the inbound deliveries of wire and strand, including the storage, record keeping, stock rotation and use of wire/strand, must be documented and training given to all relevant personnel.
7. Procedures for the setting up of stressing beds must be in place, including the running of wire/strand, cutting and placing them into the stressing bed, and the guarding of the bed, including the use of safety chains or other suitable wire/strand restraint systems.
8. Documented procedures for the receipt, storage, cleaning, discard and maintenance of barrels and wedges must be in place with relevant personnel trained as required. This is to include procedures for ensuring stock rotation and identification of types of barrels and wedges to prevent misuse. Cleaning and inspection of barrels and wedges and jack jaws must be carried out to a high standard with procedures in place to ensure that worn components are replaced.
9. Stressing procedures and safe systems of work must be in place for the stressing operations undertaken and they must be relevant to the type of stressing activities. This must include fitting barrels and wedges to wire/strand, extension checks and guarding as well as documented procedures in relation to crossed wires/strands, broken wires/strands, inadvertently released tension or other non-routine operations.
10. Procedures for the de-tensioning of beds must be available and these should take into account concrete strength and the removal of barrels and wedges from wire or strand.
11. Maintenance procedures must be created, and training given, for any activities where prestressing equipment is to be serviced, maintained, etc., including how pressurised equipment or equipment in tension should be safely worked on in the event of a breakdown, i.e., how the stored energy is removed and the equipment isolated safely.
12. Information must be available to enable operational management to ensure that all relevant personnel are trained to the necessary standards to enable them to carry out their work activities safely. These procedures must document training frequency, refresher training, competency reviews and certification for operatives.
13. Stressing awareness training is required for all personnel who work on stressing or have cause to regularly work within stressing areas, whether actively taking part in stressing activities or other roles which require them to be in the vicinity of stressing operations.
14. The stressing operative should hold a valid training certificate and be subject to annual assessments.
15. The correct personal protective equipment must be identified, available and worn.

Example Safe Stressing Policy Statement

This is the Safe Stressing Policy Statement of [NAME] of [COMPANY]. I recognise and acknowledge my responsibilities under the MPA Precast Code of Practice for the Safe Stressing of Prestressed Concrete Products and the Health & Safety at Work Act 1974 and the Regulations which affect it.

I am committed to the Code and will abide with all recommendations that the Code advocates. In circumstances where we recognise that we do not reach the standards within the Code, I will endeavour to instigate improvements to bring us up to the Codes requirements and I will monitor improvements in the effort to meet the Code standards.

I will maintain the highest standards of health and safety during stressing activities and I am committed to ensuring the safety of employees who may be affected by our work as much as is reasonably practicable. I will assess and alter our work conditions, systems and equipment wherever necessary to prevent accidents or harm through our risk management system.

I genuinely care for my employees and others affected by our work and will ensure that our stressing safe systems of work are designed accordingly. I shall actively encourage all employees to engage and cooperate on workplace matters, in particular health and safety.

As the managing director, I accept that I have overall responsibility for health and safety during stressing activities and I shall, so far as reasonably practicable:

- Provide a safe and healthy working environment and welfare facilities.
- Ensure that plant and work equipment is suitable and fit for purpose and maintained as per manufactures guidelines.
- Manage health and safety risks to prevent accidents and work-related ill health by developing appropriate risk assessments and reviewing them when appropriate.
- Communicate and consult with employees on Health & Safety matters, or with others who may be affected by our stressing activities.
- Provide information, instruction, training and supervision for all employees under my control.

There is no reason whatsoever to cut corners and risk the health and safety of anyone, in an effort to save money or time and we must remember our moral obligation to our families and to each other.

There is no production need, competitive advantage, cost or time saving measure that is worth an injury of any kind to any person. We must have zero tolerance of any practices that could cause accidents or ill health.

This Safe Stressing Policy Statement will be reviewed on an annual basis, unless there is a reason to review it sooner (in event of an accident, change in work process, change in legislation etc.)alter our work conditions, systems and equipment wherever necessary to prevent accidents or harm through our risk management system.

Signed

[Name of most senior person / Position, Company & Date]

Appendix 2: Pre-Start / Stressing Equipment Inspections

These examples are intended to support the generation of site-specific stressing pre-start checks and stressing equipment inspections. The need for these documents is explained in Sections 1.6 and 1.7 of this Code of Practice.

The examples are not intended to be copied and used as they are (unless they are to be implemented and reviewed following a relatively short period and then made site specific). The intention is to provide a reference document/example of a format to use and to be included as part of a company's specific health and safety documentation, which includes local conditions and industry expected requirements. As detailed in Section 1, the review of these examples and generation of a specific format needs to be completed with the involvement of all key personnel during stressing operations.

The three examples in this appendix cover:

1. Pre and post stressing and casting equipment checklist – Completed by stressing operatives/supervisors following suitable training, especially PS3.
2. Stressing equipment inspection and maintenance checklist – Completed by maintenance staff/those with suitable competence (especially PS3) to identify potential equipment failures linked to wear, corrosion, abrasion, fatigue, etc. of the static stressing equipment and pneumatic systems.
3. Mouldage and abutment inspection and maintenance checklist – Completed by maintenance staff/those with suitable competence (especially PS3) to identify potential equipment failures linked to wear, corrosion, abrasion, fatigue, etc. of the static stressing equipment.

Pre and Post Stressing and Casting Checklist Example

Date:		Bed Ref:		Bed set up by:	
Supervisor:		Staff involved:			

Pre-Stressing Checks – <u>Stressing cannot be progress unless full compliance with the areas listed below</u>			
		Y / X	Corrective Action / Comments
1	Strand pattern correct?		
2	Strand ends wiped clean supporting wedge grip?		
3	Jack & pump operational to correct pressure, no signs of leaks/damaged hose		
4	If hydraulic hoses connection required are check whip retainers in place		
5	Jack spring balance operations to reduce stressor manual handling?		
6	B & W set ready and visually checked before use?		
7	B & W seated correctly at non-stressing end & strand projecting 100mm min?		
8	B & W seated correctly at live end with strand projection length correct?		
9	Safety chains/strand retention system positioned every 10m and secure		
10	Dead end guards fitted, and secure / chains fitted preventing direct access		
11	Physical barriers positioned preventing direct access to area/exclusion zone		
12	Warning signage fitted at all stressing zone entry points		
13	Sound klaxon before & during stressing?		
14	Warning lights clean, operating and visible?		
15	Confirm no person is within the exclusion zone		
16	All persons involved trained for the task?		
	<u>Add site specific / production and quality elements as required</u>		
Pre-Stressing checks completed by:			

Post-Stressing Checks			
		Y / X	Corrective Action / Comments
1	B & W seated correctly & no signs of slippage?		
2	Locking pins located correctly and secure?		
3	Live end guards fitted and secure covering strand ends		
4	Check safety chains/strand retention system have not moved during stressing		
5	Supplementary guards' position against live end primary guards		
6	Chains fitted preventing direct access to live end guarded area		
7	Klaxon sounded after stressing completed to confirm safe to re-enter zone		
8	Stressing equipment checked ok, isolated, depressurised and stored correctly		
	<u>Add site specific / production and quality elements as required</u>		
Post-Stressing checks completed by:			

Pre-Cast Checks			
		Y / X	Corrective Action / Comments
1	B & W seated correctly & no signs of slippage?		
2	Locking pins located correctly and secure?		
3	Safety chains remain in position until casting requires removal		
	<u>Add site specific / production and quality elements as required</u>		
Pre-Cast checks completed by:			

Post-Cast Checks			
		Y / X	Corrective Action / Comments
1	B & W seated correctly & no signs of slippage?		
2	Locking pins located correctly and secure?		
3	Safety chains stored to prevent damage		
	<u>Add site specific / production and quality elements as required</u>		
Post-Cast checks completed by:			

Any areas of concerns / improvements identified during the stressing process checks:

Stressing Equipment Inspection and Maintenance Checklist Example

Date:		Pump / Jack / Bed Ref:	
Inspection completed by:			

Mobile Pump and Jack

	Note – Depressurise hydraulic pressure before commencing checks	Y / X	Corrective Action / Comments
1	Check jack for loose parts, tighten as required		
2	Check hydraulic hoses/pipes fit & condition, whip retainers in place if hose connection is required		
3	Check for any signs of damage on the jack		
4	Check oil level in power pack for contamination/level		
5	Condition of gauge & controls		
6	Check the structure of power pack and wheels/freedom of movement		
7	Check condition of plug, cable & switches		
8	Check for any damage to Power Pack		
9	Test the operation of the jack and power pack		
10	Hydraulic cylinders free from damage		
11	Check for oil leaks following test above		
12	General condition/cleanliness		
13	Ask operative if they have encountered any problems		
	Add site specific / production and quality elements as required		

Inspection and maintenance checks completed by:

Multi-Stressing

		Y / X	Corrective Action / Comments
1	Guards in place/undamaged		
2	Check oil levels on pumps		
3	Check maximum pressure cut off on pumps		
4	Check tank oil levels		
5	Check suction & return filler indicators		
6	Check for any excessive noise/erratic readings		
7	Check for leaks around pump, stress heads and general area		
8	If hydraulic hoses connection required are check whip retainers in place		
9	Check oil filters for indicator red		
10	Hydraulic rams sliding free and even		
11	Locking pins engage square and free from binding		
12	Locking pins housing free from damage and cracks		
13	Any loose, missing bolts on the stress head		
14	General condition/cleanliness		
15	Ask operative if they have encountered any problems		
	Add site specific / production and quality elements as required		

Pre-Stressing checks completed by:

Corrective action / Defect	Remedial Actions required	Action completion date	Signature of person completing action

General Comments

I have carried out the above checks & have established to the best of my ability that the equipment is safe and in a good mechanical condition for use in the stressing operations

PRINT Name:		Signature:	
Position:		Date & Time	

**Safety first always LOTOTO before performing any maintenance duties –
Never allow faulty equipment back into service until repaired**

Mouldage and Abutment Inspection and Maintenance Checklist Example

Date:		Bed Ref:	
Inspection completed by:			

		Y / X	Corrective Action / Comments
1	Dead end guard securely fixed and lockable		
2	Dead end abutment head plate securely fixed		
3	Dead end abutment and mouldage welds in good condition		
4	Dead end feet anchors securely fixed, no signs of flexing/rusting		
5	Dead end feet anchors clear from build-up and moisture		
6	No excessive scoring of the beds		
7	Bed Joining bolts secure and no signs of flexing if applicable		
8	Live end feet anchors securely fixed, no signs of flexing/rusting		
9	Live end feet anchors clear from build-up and moisture		
10	Live end abutment and mouldage welds in good condition		
11	Live end abutment head plate securely fixed		
12	Live end guard securely fixed and lockable		
13	General condition/cleanliness		
14	Ask operative if they have encountered any problems		
15	Any evidence of fatigue failure requiring increased inspection frequency?		
	<u>Add specific manufacturers inspection requirement</u>		

Inspection and maintenance checks completed by:

Corrective action / Defect	Remedial Actions required	Action completion date	Signature of person completing action

General Comments

I have carried out the above checks & have established to the best of my ability that the equipment is safe and in a good mechanical condition for use in the stressing operations

PRINT Name:		Signature:	
Position:		Date & Time	

**Safety first always LOTOTO before performing any maintenance duties –
Never allow faulty equipment back into service until repaired**

Appendix 3: Risk Assessment

This risk assessment format is intended to support the generation of site-specific assessments.

The format is intended to support a structured process, where hazards are identified, and current controls are added with improvements listed together with responsibility and time scales for action. For more detail refer to Section 1.3 of this Code of Practice.

Risk Assessment Record

Assessment Team:		Assessment Date:	
Activity Assessed:		Location:	
		Review Date:	Monthly until all improvements are completed, then annually max.

What are the hazards?	Who might be harmed and how?	What's already in place, fully communicated and effective?	What further improvements have been identified?	Action by who, when / completed

Personnel Involved / Acknowledgement of understanding			
Job title:	Name:	Sign:	Date:
Job title:	Name:	Sign:	Date:
Job title:	Name:	Sign:	Date:
Job title:	Name:	Sign:	Date:
Job title:	Name:	Sign:	Date:

Any additional comments/ observations:

All staff are reminded to stop and report any circumstances where the conditions of this risk assessment cannot be achieved and to remind all others in their work area of the safe work processes in place to avoid injury and incident.

The Risk Assessment process is managed by (add name) to ensure industry standards are achieved. This Risk Assessment has been compiled and reviewed by all key staff involved in the task, to ensure the controls are suitable and sufficient to minimise the risk of harm. If any additional improvements are identified, to make the task safer, they should be recorded in the improvements column and monitored through to completion with the agreed timescale. All key personnel involved in the Risk Assessment generation must sign their acknowledgement in the table above.

Appendix 4: Safe Systems of Work

This safe system of work format is intended to support the generation of site-specific systems for high risk activities and key process stages.

The format is intended to support the development of structured operational systems for all key stages of the stressing process, together with emphasis on the priority safety elements. Each stage includes a concise and clear description of the stage, together with a supporting photograph, showing the expected standards to be achieved. For more detail refer to Section 1.4 of this Code of Practice.

Safe Operating Procedure Format Example: Stressing Operation

Task:	Area:
Prepared By:	SOP REF:
SOP Date:	SOP Review Date: SOP must be reviewed on an agreed regular (maximum annual) basis during a Planned 'V' Actual audit and/or following an incident, accident etc.

Introduction

When following this procedure's requirements, the **(add element / stage description)** is completed to a specific sequence ensuring safe and efficient operation, together with specific safety reminders for each element. The safety controls incorporated in this procedure ensure that operatives can complete the operations without injury, incidents and to the required specification.

All persons involved in this operation are to be involved in this procedure's development/during training and instruction/during the regular Planned v Actual audits. Formal confirmation of involvement must be recorded on the confirmation section of this procedure.

These are minimum acceptable standards and are not intended to dilute the requirements of more detailed and specific statutory duties or company / site rules.

Training and Instruction Requirements

- You can only undertake this operation if you have been formally instructed and trained in this procedure and;
- You have completed the Proskills Global PS1 and PS2 elements in the past five years and;
- Completed an annual assessment supporting your continuing competence in stressing operations.
- You must be fully aware of the safety controls, including when, due to poor standards, you **MUST** stop stressing operations and the acknowledgment section of this SSOW has been completed.
- Stressing operation must not be completed in a lone working situation, there must be a competent second person in attendance.

Exceptions

- There are no exceptions permitted to this SOP. If this SOP cannot be followed in full the stressing operation must not be progressed.

Equipment to be Used

- Stressing Pumps
- Overhead cranes
- Stressing warning system and alarms

Key Documentation

- Safe Operating Procedure reference
- Work instruction reference
- Toolbox Talks – Linked to SOP for the task
- The safe stressing COP – reference to relevant sections to be added

Supervision Arrangements





- Operations Manager
- Production Supervisor
- Team Leader
- SHE Officer
- Quality Manager

Environmental Controls

- Spill Kit

Emergency Action

- Fire Evacuation Procedures
- Accident / Near Miss Reporting Procedures

PPE Required									
									
High Visibility Clothing EN ISO 20471	Safety Footwear EN ISO 20345	Hard Hats EN 397	Gloves EN 388	Eye Protection EN 166F	Face Protection EN 166B	Hearing Protection EN 352	Dust Mask EN149 FFP3	Apron EN 14605	Safety Harness EN 361

Please Note: If you have any concerns or cannot comply with this procedure, STOP and report to your Supervisor Immediately. Only trained and authorised persons should carry out this task.

The Procedure		
Safe Operating Procedure	Step (picture)	Safety Reminder
1.		
2.		
3.		
4.		
5.		

To Remember Always	
Do's	Do Not's

SOP Confirmation of Instruction, Training and Acceptance

Operative - I have read and fully understand the procedure detailed above and will fully comply with this Safe Operating Procedure. I will also stop work and raise any concern when this Safe Operating procedure cannot be fully complied with.

Signed:		Date:	
Print Name:		Position:	

Trainer / Line Manager – I am satisfied that those named above have a good understanding and demonstrated compliance with the Safe Operation procedure’s requirements listed above.

Signed:		Date:	
Print Name:		Position:	

SOP Planned v Actual Review / Audit

A planned v actual review of this SOP is to be completed on a regular basis, involving a detailed review of the safe system whilst observing the activity it controls in order to ensure that the written system mirrors the activities being completed. This process will help to formally confirm that all elements are implemented and to identify if any improvements and/or alterations are required.

The review should be overseen by a Supervisor/Foreman, who is involved in the production process and can support clarification / alterations as required.

Date	Operative completing the P v A review - Print and sign	Other persons involved	Supervisor Confirmation – Print and sign	Any comments / recommendations



MPA Precast is part of the Mineral Products Association (MPA), the trade association for the aggregates, asphalt, cement, concrete, dimension stone, lime, mortar and industrial sand industries.

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