In galvanic cathodic protection, sacrificial anodes of alloys of aluminium, magnesium or zinc are electrically connected to the steel needing protection (the cathode). If the steel and anode are both immersed in an electrically conductive medium such as seawater, galvanic action occurs creating an electric current that flows through the system. This causes the anode to corrode at the expense of the steel. The steel is thus protected. When the zinc anode has been consumed, it is replaced with a new anode.

In impressed current cathodic protection, a direct current from the positive terminal of an external power source is passed through an anode that is, in the case of a reinforced concrete member, a non-corroding mesh or similar embedded in the surface of the concrete. The circuit is completed by another connection from the reinforcing steel to the negative terminal of the power source. This form of corrosion protection is sometimes used in the remediation of corroding reinforcement in bridge piers, building facades and the like.

2 Fire protection

2.1 Introduction

In Australia, the level of fire protection for various classes of buildings is prescribed in the Building Code of Australia (BCA). The Fire Resistance Level (FRL) is defined in terms of:

- structural adequacy – the structure must not deflect excessively or collapse;
- Integrity – flames or hot gasses must not penetrate a floor or a wall required to provide fire protection; and
- Insulation – the top surface of a floor or the face of a fire wall remote from a fire must not become hot enough to ignite items in contact with the floor or wall.

Beams and columns will usually need to satisfy structural adequacy only while floors and walls will need to satisfy all three requirements.

2.2 Determination of fire resistance

Fire resistance can be determined by two methods:

- deemed to satisfy, in accordance with the BCA, and
- fire engineering.

The required deemed to satisfy FRL for a particular building is dependent on:

- building classification (its proposed use);
- building height from the average ground level to the topmost occupied floor level;
- fire compartment area; and
- proximity to other buildings or fire source features.

The building classification is determined by the likelihood of a fire occurring, the likelihood that it will be allowed to develop, and the characteristics of the occupants (alert, mobile, infirm, etc) The height of a building determines the difficulty of fighting a fire and the difficulty of rescuing trapped occupants. The fire compartment area is the floor area surrounded by fire-resistant barriers. It is a measure of how large a fire can become before it is blocked by fire barriers. The proximity of other buildings and fire source features is about controlling the spread of fire beyond the property, or the proximity of other buildings or objects that may be the source of a fire.

Fire engineering uses rational methods to satisfy the FRLs required by the BCA. Aspects considered may include:

- the design of the structure;
- the provision of fire sprinklers and their controls such as valving;

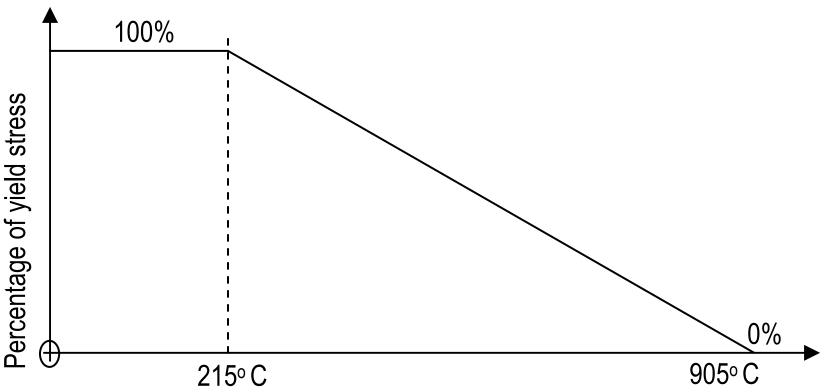
- management systems adopted to increase sprinkler reliability;
- escape routes and escape times;
- consideration of, and systems adopted to reduce the likelihood of fire starts;
- the proximity of fire stations;
- laboratory or prototype fire testing; etc.

Fire engineering is a specialised subject, usually the province of professionals with appropriate training and experience. A fire-engineered solution is subject to approval by the relevant building authorities or building surveyor and the fire brigade who need to be satisfied that the performance requirements of the BCA have been achieved by the design.

Structural building codes such as AS 3600 – Concrete Structures and AS 4100 – Steel Structures describe measures that can be used in design to meet the deemed-to-satisfy requirements of the BCA. These requirements address only life safety; they do not address protection of the owner's financial investment in the building. The owner may require that fire protection measures additional to those required by the BCA be applied. This is a cost-benefit consideration.

2.3 Fire resistance of structural steel

The strength of steel varies with temperature. AS 4100 Clause 12.4 suggests the following relationship:



AS 1170.0 in clause 4.2.4 defines the fire limit state load as G + ψ_lQ. For office, retail, residential and parking floors, this load is G + 0.4Q, which is about 60% of the strength limit state load of 1.2G + 1.5Q.

Now AS 4100 defines in clause 12.5, the limiting temperature T_l = 905 – 690r_f, where r_f is the ratio of the design action on the member under the design fire loading to the design member capacity, ϕR_u, at room temperature. The steel must be kept below this limiting temperature for the duration of the period specified in the BCA or determined by a fire engineering study for the FRL. If the ratio r_f is 60%, T_l = 905 – 0.6 x 690 = 491° C. This explains why 500° C is often quoted as the maximum allowable steel temperature, even though at this temperature the yield stress will nearly have halved.

The limiting temperature can be controlled by the application of applied insulation, with its effectiveness having been established in standard fire tests, or, for unprotected steel members, on the basis of exposed surface area to mass ratios. AS 4100 provides information to allow calculations to be undertaken for both of these approaches. For example, for an unprotected 460UB67 supporting a concrete slab, the time at which a temperature of 500° C is attained is calculated as:

$$t = -5.2 + 0.0221T + (0.433T / k_{sm})$$
$$t = -5.2 + 0.0221 \times 500 + (0.433 \times 500 / 21.4$$
$$= 16 \text{ minutes}$$

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