SCIENTIFIC RESEARCH & DEVELOPMENT BRANCH

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HOME OFFICE

SCIENTIFIC ADVISORY BRANCH

WORKING NOTE 3/80

Safety of Turntable Ladders in High Winds

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1. INTRODUCTION

Following a fatal accident at Goole, Humberside, in 1974, involving a Merryweather Type B turntable ladder being operated in windy conditions, it was recommended that certain urgent modifications be carried out to such equipment and to its method of use. Fire Department (G1) has now, at the instigation of the Joint Committee on Design and Development, requested SAB to carry out some further work in order to determine whether additional measures are possible. The work required is to be in the form of a feasibility study having the following objective:-

> "To develop a system that could provide the operators of existing turntable ladders with a suitable warning that the loading conditions in general, but particularly those arising from high winds, under which a ladder was currently operating had reached the limits for its continued safe operation."

The full project definition is attached as Appendix A.

In response to this project definition a proposal was prepared by SAB setting out three possible stages in the project:-

1. Familiarisation.
2. Detailed assessment of problem and outline solutions.
3. Development and trials.

The full proposal is attached at Appendix B.

Stage 1 has now been completed and this review paper summarises the work carried out so far.

2. ASSESSMENT OF CURRENT SITUATION

The assessment is based upon:

1. study of HO files and other documentary evidence
2. discussions with members of the Engineering Inspectorate and with officers and firemen of several brigades
3. observation of turntable ladders (TL's) in training.

From an examination of the files and other documentary evidence, it would appear that the Goole accident can be attributed to one or more of several possible factors:-

1. The lack of awareness of the TL operator of the severity of the wind at the head of the ladder.
2. The inexperience of the man at the ladder head who failed to recognise the onset of danger as the ladder was manoeuvred.
3. The ladder design which made it impossible for the operator to house the ladder when it was under extreme lateral stress.
4. The relatively poor resistance of the ladder to lateral wind loading.

The interim measures recommended by the Home Office were intended to obviate the first of these and consisted of the following:-

1. Fitting of a lateral loading alarm which indicates by means of an audible warning when the lateral strain in the main section exceeds a certain level.

2. Fitting of a burgee to the head of all TL's to indicate wind direction and to a lesser extent wind speed.

During the discussions with brigade personnel and others, consideration was given to the extent to which these measures have been effective and the respects in which they fall short of the ideal.

2.1 ASSESSMENT OF DEVICES

2.1.1 Burgee

It was clear from discussions that the burgee suffers from a number of disadvantages, viz:-

1. The burgee and its mounting tend to obstruct the fireman operating at the head of the ladder.

2. Even in ideal conditions the burgee is a very crude indicator of wind strength.

3. When the ladder is being pitched against a building, the burgee is often sheltered by the building or by neighbouring buildings, until such time as the ladder head clears the top of the building.

2.1.2 Lateral Strain Warning Device

This system appeared to work well on the ladders examined although the following observations were made:-

There appeared to be a substantial variation between ladders in respect of the setting of the warning switches. At the most sensitive setting it was found that the alarm operated when stopping the ladder during the training manoeuvre while at the other extreme ladders were found the alarms of which had never been heard to operate except during tests of the microswitches. It is understood that the system should just operate at a wind speed of 25mph with the ladder fully extended and held transverse to the wind direction. A criticism of the system was that it gave no indication of the actual amount of loading and how near the ladder was to its safety limit. It was felt by some operators that a continuous indication of deflection would be of more value.

2.2 ASSESSMENT OF PROCEDURES

Some brigades have a formal system of warning operators when adverse conditions are expected. Typically the brigade receives a warning from the local Meteorological Office, and a warning is given to each watch as it comes on duty. This procedure, useful though it undoubtedly is, can only give very general guidance since actual wind speeds can vary considerably within a given brigade area and can also be modified substantially by the presence of buildings or natural features such as valleys.

However the training of TL operators appears to include sufficient instruction on operation in windy conditions and it was evident that this in conjunction with the greater general awareness of wind effects following the Goole accident, contributes materially to the safety of TL operations.

3. FUTURE OPTIONS

The steps which have been taken to prevent a recurrence of the Goole incident may be summarised as follows:-

1. Fitting of a lateral load warning device.
2. Fitting of a burgee.
3. Use of weather forecasts to warn operators.
4. Training of operators.

A number of possible refinements can be considered to the present arrangements which might increase the margin of safety. However, without pre-judging their merits it is only possible at this stage to list these and to discuss possible benefits that might result from their use. Since the SAB remit was concerned mainly with devices, other possible measures such as improved training have not been considered in detail at this stage.

3.1 WIND INDICATOR

It would appear to be possible to fit a small robust anemometer near to the ladder head in a way that would not obstruct operation of the ladder. The device would be of the hot-wire type and would consist of a sensing head approximately 180 mm long by 13 mm diameter connected to an instrument on the central console which would indicate wind speed on a meter. The cost of such an installation would be in the region of £200. It might be possible to link several such devices together to give an additional indication of wind direction. This would require development and the cost would be appreciably higher.

3.2 LATERAL STRESS GAUGE

If it were felt that an indication of the amount of deflection was required, a system can be conceived which would provide a continuous indication of lateral movement, or of stress in the critical parts of the structure.

Compared with a measurement of wind speed, a stress gauge is likely to give a more accurate indication of the condition of the ladder since it measures the integrated effect of the wind acting at all points along its length. For example, if the top 10% of the ladder only is exposed to the wind, the wind speed that can be tolerated is obviously much higher than if say 60% of the length were exposed.

4. DISCUSSION AND RECOMMENDATIONS

In general, since TL's tend to be used in the vicinity of buildings, parts of the ladder may either be sheltered from the wind or may be subject to higher wind speeds due to the "funnelling" effect of the buildings. Thus even if the wind speed and direction at all points on the ladder is accurately known, there would seem to be a major difficulty in relating the wind data to the stress in the ladder and hence to its safety. In the opinion of the author, unless the whole ladder

can be assumed to be exposed to the same wind conditions, there is little point in measuring the speed at the head of the ladder, (or for that matter at any other single point).

If wind speed measurement were to be the basis of some improved safety system, it would appear to be necessary to measure the wind speed and direction at a number of points on the ladder and then to carry out a calculation based upon knowledge of the wind effects upon the structure. The nature of this calculation would probably require a device having the complexity of a programmable calculator and would additionally require a substantial amount of work to model the performance of the structure in such a way that a program could be devised. But even if a system could be devised which took into account the wind effect on all parts of the ladder, and which in some way derived an indication of the stress at some critical point, this would still not take into account any variation due to the other loading effects such as the wind forces acting upon people on the ladder, or to jet reaction from the monitor.

Since the critical parameter is the stress in the ladder, it would seem more efficient and reliable to measure this directly rather than attempting to derive it by inference.

It is important to note, however, that no system can enable an operator to anticipate gusting and that any warning system would, if it were to be of any use, have such a low warning threshold that operation of the ladder would be seriously restricted.

In addition to the foregoing, the generally cautious attitude of TL operators was noted during this brief survey. This combined with the publicity attached to the Goole accident and the formal acknowledgement of wind effects in operational procedures would seem to make the need for further work, or the development of more sophisticated safeguards, somewhat questionable.

If however, it were felt that an improved warning system were necessary, then the development of a stress-measuring device would seem to be the sensible choice. If it was believed that wind speed per se was of interest, then a simple hot-wire anemometer might provide a solution. Any more effective system, such as the fitting of strain gauges to critical points of the ladder, would be considerably more expensive.

APPENDIX A

FEASIBILITY STUDY ON THE DEVELOPMENT OF WARNING DEVICES TO ENHANCE THE SAFETY OF TURNTABLE LADDERS IN HIGH WINDS

Project Definition

1. At a meeting on 6 October 1977, the Joint Committee on Design and Development of Appliances and Equipment asked that a feasibility study be undertaken having the following objective:-

> To develop a system that could provide the operators of existing turntable ladders with a suitable warning that the loading conditions in general, but particularly those arising from high winds, under which a ladder was currently operating had reached the limits for its continued safe operation.

Background

2. This request stems from a fatal accident at Goole in 1974 where a turntable ladder collapsed in high wind. At the subsequent enquiry it was established that the operator was not aware of the severity of the wind at the head of the ladder and that the man at the ladder head, who was carrying out a training exercise, was too inexperienced to recognise the on-set of danger as the ladder was manoeuvred.

3. A further factor in this incident was the relatively poor resistance of the ladder concerned to lateral wind loading ie wind loading at right angles to the vertical plane containing the angle of inclination of the ladder. To reduce such loadings it is usual to attempt to train turntable ladders into the wind. The difficulty here is that often it is not possible to know the direction, or the severity, of the wind at the head of the ladder. In order to overcome this it was decided to fit a small burgee to the head of all turntable ladders which would indicate wind direction and, to some extent, wind severity. However, this exercise has not been wholly successful since it has proved impossible with some ladders to find a fixing point for the burgee that does not obstruct either the fireman or the operation of the ladder.

4. It will be noted that the Committee suggested that the feasibility study should investigate ways of measuring wind speed and direction at the head of the ladder. However, since such an approach would require the simultaneous solution of another problem, namely, how wind behaviour reacts with the structure of a ladder, the view may be taken that the study should concentrate directly on measuring the build-up of stress in the ladder components rather than on the wind parameters. Whatever the case, information on wind behaviour is of relevance in the strategy of operating a turntable ladder and should be taken explicitly into account in the project.

Priority

5. This project has high priority.

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FIR/77 82/67/1

PROPOSAL FOR A FEASIBILITY STUDY ON THE DEVELOPMENT OF WARNING DEVICES TO ENHANCE THE SAFETY OF TURNTABLE LADDERS IN HIGH WINDS

Introduction

1. As indicated in the Fire Department Project Definition the main objective will be to give assistance to the operators of existing TLs in determining when operating conditions are safe, with the subsidiary objective of giving the operator information about wind conditions at the head of the ladder.

2. Stage 1 - Familiarisation

Before we can plan out a programme of work in detail it will be necessary to become familiar with the problems which, we suggest, is best done by us reading HO files and other documentary evidence and then having additional discussions, as appropriate, with FSI, brigades, and manufacturers. It would also be necessary to observe the use of TLs both during training and, if possible, under operational conditions. A review paper will be prepared following this work.

3. Stage 2 - Detailed assessment of problem and outline solutions

Following familiarisation we propose that a detailed assessment be made of the problem. This is likely to require research under the following headings:-

a. an assessment of the relevant safety margins of existing TLs which will include studies of wind effects;

b. an examination of the safety design of new TLs to determine whether possible new ideas can be applied retrospectively to existing TLs;

c. the development of a short list of possible warning devices that could be fitted to existing TLs with an assessment for each of their operational suitability and likely cost, reliability, and maintainability. Operational suitability is used here to describe the effectiveness of the system and will include factors such as: how much the safety device affects the operation of the TL; how reliable the device is in protecting the TL from damage; and how easy it would be for the TL operator to recognise and be trained to act appropriately to warning information;

d. an assessment of how well an operator could be trained to recognise dangerous conditions by simply looking for signs such as mild bending of the ladder and by appreciating how wind can affect the ladder and how buildings can modify wind behaviour.

As a result of this work recommendations may be made for the development and testing of one or more types of safety systems. Specific design recommendation will be made for devices that warn an operator of the build-up of dangerous stresses in the ladder and for devices to indicate wind conditions at the head of the ladder.

4. Stage 3 - Development and Trials

The content of this stage is very much dependent on the outcome of the previous assessment stage. Detailed proposals would be prepared towards the end of the assessment stage.

5. Management and Control

The work will be undertaken within SAB up to Stage 2. Stage 3 might contain an extramural element. Normal project steering arrangements will apply under the chairmanship of Mr Stephen. The project manager will be Mr Lindfield.