Guidance Notes

The Concrete Society Industrial Floors Group

This is the first in what will be a series of Guidance Notes from The Concrete Society Industrial Floors Group.

Guidance Note – Use of Chapter 4 and Appendix C

This Guidance Note is intended to provide additional information on defined movement specifications in Concrete Society Technical Report 34 3rd Edition 2003[1] (TR 34).

Two sections in TR 34 address the question of surface regularity within aisles of an industrial floor slab where guided materials handling equipment (MHE) is to be used. These are designated defined movement (DM) areas.

Table 4.3 of Chapter 4, and Table C1 of Appendix C, both assess the transverse and longitudinal profiles of the slab in defined movement areas or aisles. While both measure the transverse characteristic, Chapter 4 only measures the longitudinal characteristics in the wheel-tracks of the outer two loaded wheels of the MHE over a short wavelength (i.e. 600mm), whereas Appendix C also measures the elevational differences between front and rear axles. Rear wheels are subject to the same potential effects as front wheels. Undulations may cause poor ride quality and under wheel cross-falls may cause steering problems. In addition, where changes in elevational difference between the rear and front wheels are of sufficient magnitude, there will be longitudinal pitching or nodding effects.

Appendix C was introduced as an alternative specification to Chapter 4 in order to provide another approach to measuring defined movement areas of floors. It is based on a system that has been in use since the 1970s in the USA, and is very similar to the German system DIN 15185 that has been in use since the late 1980s. Some confusion exists in the industry over the specification of Appendix C with varied views associated with ride quality, corrective grinding and construction costs. This guidance is intended to present the two approaches with a view that the final decision should be made with the input of the client, design and construction team and the MHE supplier to form a basis of informed choice.

Differences between Chapter 4 and Appendix C

The only, but nevertheless significant, difference is that Appendix C takes into account the rear wheel(s) whereas Chapter 4 does not. Therefore, the Appendix C method mimics the reactions of the truck to the floor.

Cross-aisle measurements

Appendix C Property A is the same as Chapter 4 Property III and has the same values. Appendix C Property B controls the rate at which Property A can change as the truck moves forward and thus assesses the effects of the longitudinal undulations in the outer front wheel-tracks on the transverse tilt of the mast. In Chapter 4, the effect of transverse sway is assessed by Properties I and II. The outcome in both methods is similar in that the rate of sway is controlled.

In order to survey a floor, it is necessary to know the truck front axle wheel-track dimensions for both Appendix C and Chapter 4. In Appendix C, Property B is a fixed percentage of Property A for a forward movement of 300mm. In order to survey a floor it is necessary to know, or assume, a value for the front axle wheel-track dimension. In cases where the actual dimensions of the truck are not known at the time of construction, a 'standard truck wheel layout' could be assumed for the specification to enable compliance to be demonstrated.

In Appendix C, the Property A limit is calculated specific to the front axle dimension, whereas Property III in Chapter 4 is in two bands depending on the spacing of the outer wheels.

Down-aisle measurements

Properties C and D of Appendix C limit the front-to-rear tilt of the truck and the rate at which it can change for a forward movement of 300mm. This limits the front-to-rear pitching of the truck. Properties I and II of Chapter 4 limit short distance undulations, i.e. bumpiness, in the two outer wheel-tracks. It should be noted that a significant majority of trucks used in the UK and Europe are of a three-wheel configuration with single or close-coupled wheels at the centre rear of the truck.

The value of Property C as currently published is calculated on the basis of the truck length. At the time of publication, this was seen to be a potential cause of concern as users might be under the impression that their floors were constructed to be 'truck specific'. This was anticipated at the time and is discussed in clause C3 of TR 34[1]. This subject has since been discussed within the British Industrial Truck Association (BITA) and the Fédération Européenne de la Manutention (FEM) and it is recommended that a standard or 'notional' truck length of 2m should be used.

As the measurement of Properties C and D are new to the UK, it is essential that contractors, in particular, are aware of these requirements. The published limits were based largely on US experience that was originally derived from surveys of floors in the 1970s. In the US system, the longitudinal limits are (pro rata) the same as the transverse. The longitudinal limits were relaxed by 10% in Appendix C as there was concern that they were too onerous and that construction costs might increase as a result.

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Newly constructed floors in the UK were also surveyed to investigate building practice and costs. It was found that floors constructed to Chapter 4 without dependence on grinding generally also met Appendix C requirements. In addition, 13 floors were surveyed as part of a BITA initiative to establish relationships between tolerances and performance. Experience of construction to Appendix C is growing but still limited and more feedback on the achievement of and the requirement for these limits will be useful.

Changes in floor construction techniques

When the measuring method detailed within Chapter 4 was originally developed, most defined movement area floors were built using a long-strip method, where 4–5m-wide bays were constructed with high levels of control both longitudinally and transversely along the aisles. The long-strip method enabled accurate formwork setting and checking during construction, as well as good transverse surface regularity control between formwork, as straight edges or specialist flattening tools only had to span a few metres before reaching fixed, and therefore checkable, points of reference.

An inherent characteristic of this type of floor was a very good longitudinal profile that gave few problems

for defined movement regularity specification

associated with pitching or elevational differences between the front and rear of the MHE. Changes in wheel-track or wheel-base had very little effect on the ride quality of a truck. Put simply, it was not considered necessary to measure the wheel-base elevational differences.

To meet the demands for increased output and reduced construction programme time, the industry has moved towards large-area pour techniques using laser screed levelling equipment. Evidence suggests that floors constructed using large-pour techniques may exhibit longer wavelength undulations down the aisles than floors constructed by the long-strip method, unless specific techniques are applied to regulate the surface either at the time of placing or through corrective grinding.

Achieving surface regularity

There are a number of approaches to laying large-area floors to defined movement specifications and they can be summarised into two categories:

- High standard of defined movement flatness as laid requiring minimal (if any) surface grinding to pass either Chapter 4 or Appendix C specifications.
- General level of flatness requiring more surface grinding to pass either Chapter 4 or Appendix C specifications.

Installers of floors in the first category will employ methods of surface regularity control during the construction and finishing operations that will result in the floor being cast to specification without much, if any, requirement for surface grinding. Those in the second category will rely more on the surface grinding to bring a free movement (general use not defined traffic) floor into a defined movement specification. The extent of grinding, if required, will depend on which specification is being employed and the construction method used. Where Chapter 4 is being used, only grinding associated with the front two load wheel-tracks needs to be considered in order to meet the specification, whereas Appendix C may also require consideration of the rear axle wheel-track of the MHE.

Corrective grinding to the outer wheel-tracks does not address the regularity of the centre wheel-track. If corrective grinding is only employed to the front axle, leaving any centre rear wheels ignored, front-to-rear axle differences may create nodding effects. Any excessive short wavelength undulations under the centre wheel may reduce ride quality and under wheel transverse slopes may cause steering problems. For compliance to Appendix C it may be necessary to grind the centre wheel track to meet Properties C and D.

If an aisle is generally constructed to the required tolerance with both transverse and longitudinal controls employed at the concrete placing stage, e.g. long-strip-type floors, then the aisle performance is less sensitive to changes in MHE type or working speed.

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New construction

Appendix C can be an appropriate floor-surveying method for new floors, where consideration needs to be given to elevational control for both the front and rear wheels of the MHE. This does not preclude the Chapter 4 method but the benefits and pitfalls of both methods need to be weighed up carefully. The method of longitudinal and transverse property control should be assessed and agreed at pre-contract stages. Consultation with the client, design team, MHE supplier and construction team should take place prior to the choice of floor specification so all implications are understood.

When the MHE and racking suppliers are known before construction they should be consulted to determine the appropriate floor flatness assessment methodology and standard for the truck types and racking height. Where they are not known, regularity assessment locations for the wheel-tracks will need to be agreed, as will the assumed MHE wheel-track and wheel-base dimensions.

Existing floors

When existing floors (possibly originally assessed to the Chapter 4 method) are reassessed for a change of MHE truck and/or a change in racking, there should be discussions between the floor users, truck suppliers and racking suppliers to determine the most suitable flatness assessment method and category for the new use. The implications of the choice made should be clearly indicated to the building user. The reassessment of a floor originally specified and constructed to the Chapter 4 method may result in additional grinding because the Appendix C methodology controls longitudinal undulations.

Owners and occupiers are advised to check the original specification and to establish that the survey conducted at that time demonstrates that the floor was correctly constructed to the specification. Where a change of use or MHE is envisaged, existing floors should be subject to a surface regularity review where the MHE supplier advises a total solution in terms of MHE operation and surface regularity standard in order for the MHE to run as safely and efficiently as intended.

Concluding remarks

More data to refine the correlation between the actual performance of MHE in service and the methods used to assess the surface regularity of the trafficked aisles would be very beneficial. Continuing data should be sought for new floors to Appendix C and Chapter 4 with a view to linking the MHE performance to the measured floor regularity. This may result in developing performance indicators for MHE, relating to operating speed, acceleration and deceleration rates, ride quality, and the risk of guide-wire signal loss. ■

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Reference:

1. THE CONCRETE SOCIETY. Technical Report 34. *Concrete industrial ground floors – a guide to design and construction,* Third edition. Camberley, 2003.