Design Guide Note
DGN007 – Structural Design Criteria

Document version: 1.0

Review and approved by: *Technical Standards Steering Committee on 1 June 2023*

Conditions of approval:

- 12 months trial implementation of DGN prior to integrating standard into EFSG.
- Collection of cost data on all projects that adopt and apply this DGN.

Published date: *13/06/2023*

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Intent and Outcome

The primary intent of this DGN is to recalibrate structural performance requirements represented by the Education Facilities Standards and Guidelines (EFSG) to a level that aligns with both the National Construction Code (NCC) and Australian Standards.

This DGN aims to:

1. Realign structural performance requirements with the functional needs of room types in schools.

2. Mitigate structural over-design arising from the increased loading requirements currently nominated in the EFSG.

3. Clarify the interpretation of the EFSG and legislated compliance to avoid miscommunication.

4. Decrease costs associated with creating durable and fit-for-purpose structures.

5. Minimise recurring EFSG Departures put forward by Project Teams which are typically endorsed to proceed.

Table 01: Summary change proposals

No.	EFSG Reference	Current Standard	Proposed Change to Standard	Benefits and Opportunities created by proposed change
1	N/A	The current EFSG does not define vibration requirements leaving the design criteria open to engineer interpretation and could result in underperforming structures or overdesigned structures.	Addition of floor vibration limits to DG21	Currently omitted from EFSG may result in underperforming or over designed structures for floor vibration. Defined minimum limits will result in consistent design outcomes.
2	DG21 21.1.12 Live Loads	Design the structures for a minimum floor live load of 3 kPa, or as specified in Schedule 1 or in accordance with current AS. Refers to: Gymnasiums, Climbing Ropes, Roman Rings, Critical Loading.	Revised imposed floor actions	Terminology updated to match current SINSW naming conventions, reduced ambiguity in room definition will result in consistent design outcomes.
3	DG21 21.1.13 Structural Deflections	For the design life of the structure ensure that the maximum deflections of structural members and their effect on finishes comply with the serviceability requirements of the structure. In the case of visual elements like fascias, adopt stringent deflection criteria, taking into account the high visibility of the elements. In addition to meeting or exceeding the suggested serviceability limit state criteria table provided in AS/NZS 1170.0, comply with the specific deflection criteria given in Table A.	Refined deflection limits	Clearer definitions will result in consistent design outcomes
4	DG21 21.06.05 Impact Loads	Design the walls to withstand possible impact by a 2 kN force applied at mid height. Design for greater forces if these are envisaged.	Removal of blanket requirement	More cost-effective designs as structures not designed for a generally unnecessary load requirement

Change proposal No. 1, Vibration Limits to DG21

When designing for serviceability, it is important to consider floor vibrations caused by dynamic loads. Typically, these loads are a result of human activity such as walking, running, dancing, aerobics, jumping, and similar rhythmic movements. However, in some cases, mechanical loads from plant and traffic may also need to be considered.

Typically, thin long-span post-tensioned concrete floors, lightweight steel and timber floors, walkways, and stairs are particularly susceptible to floor vibrations, however, the vibration requirements and limits shall also be conformed with for heavier and less vibration-susceptible structures.

There is currently no normative design standard for vibration assessments of floor plates, and it is recommended as best practice to use commonly used design guides such as SCI Publication P354, Design of Floors for Vibration: A New Approach (The Steel Construction Institute, 2009), or any other relevant design guidance. The aforementioned design guide references ISO10137-2007 and BS6472 which are considered best practice approaches and is the basis of the following recommendations and limits. The limits are based on a “low probability of adverse comments” from the occupants and are in general based on satisfactory or “acceptable” magnitudes or levels of vibration.

Vibration acceptance criteria are normally defined as an acceleration or velocity limit, often weighted against the frequency at which the vibrations occur and expressed as a ‘response factor’ (RF) against a reference value. The reference value (RF=1) is considered to be the limit of human perception, refined as a root-mean-squared (RMS) acceleration of 0.005 m/s^2.

The most commonly-encountered situations for human comfort are summarised in the table below with their accompanying recommended RF limits. The specific uses and requirements for each project shall be assessed based on any specific requirements for that given project.

Table 02: Recommended RF Limit

Learning Unit/Hub (Occupancy/Receiver)	Vibration Source	Number of Participants (Source)	RF Limit
General Learning Space Hub **Support Learning Hub** **Library Hub** **Science Learning Hub** **Visual Arts Learning Hub** **Food + Textiles Learning Hub** **Health/PE Learning Hub** **Performing Arts Learning Hub** **Additional Learning Hubs** **Wood + Metal Technology Learning Hub** **External Circulation** **Student Amenities**	Single walker in the same space	1	8
	Small groups of runners in the same space	1-3	60
	Rhythmic activities in a neighbouring room	30	8
	Rhythmic activities in the same room but separated (e.g. the other side of the room) (e.g. consider concentrated mass rhythmic load from a Performing Arts workshop) (e.g. consider vibration from Wood/Metal Technology machinery)	30	16
Administration Hub **Staff Hub** **OSCH** **Canteen**	Single walker in the same space	1	8
	Unsynchronised groups of walkers (e.g. class moving as a group in corridors)	30	16
Gymnasium / Hall **PE Fitness Laboratory**	Rhythmic activities – passive bystanders/spectators	30	55-100
	Rhythmic activities – passive active/participants	30	120-200
Stairs	Stairs – heavy use (public)	30	32

In addition to limiting vibration response from applied loads, it is good practice to observe the following lower limits for the natural frequency of the floor:

Table 03: Minimum Recommended Natural Frequency

Structure	Minimum Recommended Natural Frequency
Concrete floors - walking	4 Hz
Concrete floors – rhythmic activities	8.4 Hz
Lightweight floors – walking	8 Hz
Lightweight floors – rhythmic activities	10 Hz

Note: A steel and concrete composite floor system would be classified as a concrete floor.

Change proposal No. 2, Imposed Floor Actions Classification to DG21.1.12

Loading design criteria in the current EFSG are very prescriptive for some areas and others open to interpretation and could result in overdesigned structures. The proposed design principles aim to rationalise floor loading/action definitions to allow for future flexibility in space/room usage and bring into alignment with current SINSW terminology. Current floor action criteria relative to actual loadings required by delivery of current curriculum are to be re-evaluated for relevance to current structural design parameters

Terminology for the use of spaces developed for the Standard Hub Layouts developed varies from definitions provided in AS 1170.1:2002. Refer to the table below for clarification on room definitions and their imposed floor action requirements.

Table 04: Imposed Floor Action Classification

Learning Unit/Hub	Type of Activity	Specific Uses	Requirement (Uniformly Distributed Actions / Concentrated Actions)
General Learning Space (GLS) **Support Learning Hub** **Wood + Metal GLS**	C1	Classrooms	3 kPa / 2.7 kN
Administration Hub	B	Offices for General Use	3 kPa / 2.7 kN
Staff Hub	B	Offices for General Use	3 kPa / 2.7 kN
Library Hub	E	Reading rooms with book storage	4 kPa / 4.5 kN
Science Learning Hub	C1	Classrooms	3 kPa / 2.7 kN
Visual Arts Learning Hub	C1	Classrooms	3 kPa / 2.7 kN
Food + Textiles Learning Hub **OSCH** **Canteen**	B	Offices for General Use / Communal Kitchens	3 kPa / 2.7 kN
Health/PE Learning Hub*	C1	Classrooms	3 kPa / 2.7 kN
Performing Arts Learning Hub (PE Fitness Laboratory excluded)	C1	Classrooms	3 kPa / 2.7 kN
Wood + Metal Workshops (GLSs and Store Rooms excluded)	B	Workshops	5 kPa / 4.5 kN
Wood + Metal Storage**	E	Storage	**10.0 kPa / 7.0 kN**
Gymnasium / Hall **PE Fitness Laboratory**	C4	Dance halls and studios, gymnasia	**5 kPa / 3.6 kN**
Other bulk materials storage / Kiln area (excluding bag storage or cabinetry area)	E	Storage	**7.5 kPa / 7.0 kN**
Student Amenities	A2	**Toilet Areas**	**2.0 kPa / 1.8 kN**
Stair **External Circulation / Covered Walkway**	C3	**Stair / Corridor**	**4.0 kPa / 4.5 kN**

Notes:

-Imposed Floor Action Classification recommendations are subject to ongoing review/investigation by SINSW. Specific project loading requirements are to be assessed in line with AS 1170.1

*For dance activities in Performing Arts Workshop a timber spring floor is to be provided, which will assist with the vibration performance.

**Wood and Metal Storage area generally assumed to be on the ground floor slab. For suspended floors the structural design must be amended to suit. Consider additional structural requirements if these areas are located on the first floor.

Change proposal No. 3, Revised Vertical Deflection Criteria to DG21.1.13

Impact loading has been defined in the EFSG for partition steel stud walls. This is an onerous design criterion that should not be applied to all projects unless specifically required. Design criteria are to be assessed for current relevance to impact damage to wall cladding in high traffic locations with appropriate adjustment to baseline standards for school functional repair response and minimising whole of life maintenance criteria to realistically manage ongoing maintenance and rectification.

Within the EFSG Design guide, Table A in section 21.1.13 specifies specific requirements for deflection limits. It is recommended that the table is updated to differentiate between long term, and incremental deflection limits. Some deflection limits are onerous and are not in line with current building practice. An ambiguous set of criteria that is open to interpretation may result in underperforming or overdesigned structures.

Provision should be made on a project-by-project basis for any manufacturer/system specific requirements for items such as operable doors/walls or façade systems. Refer to manufacturer specifications or requirements to ensure that warranties and performance is maintained.

TABLE A

DEFLECTION CRITERIA - SPECIFIC REQUIREMENTS:

ITEM	STRUCTURAL ELEMENT	MAXIMUM DEFLECTION
(i)	Supporting face masonry walls	span/1000
(ii)	Supporting rendered masonry walls	span/1800
(iii)	Floors not supporting brittle elements	span/500
(iv)	Floors supporting brittle elements	limit to provide adequate serviceability of brittle elements
(v)	Stud walls under lateral loading	span/500
(vi)	Roof members under:	
	a) Dead Load	span/360
	b) Live Load	span/250
	c) Wind Load	span/150
	d) Snow Load	span/250
(vii)	Relative horizontal deflection between adjacent frames at eaves level	less than the smaller of floor to eaves height/250 and frame spacing/200

For members supporting walls or partition elements the relevant deflection is that which occurs after addition or attachment of walls or partition elements.

Figure 01: Current Deflection Criteria in EFSG DG21.1.13

Deflection Limits Applicable to All Floors and Concrete Framed Roofs:

Table 05: Proposed Deflection Criteria for All Floors and Concrete Framed Roofs

Maximum Deflection Limits				
Type	**Dead (G)**	**Incremental**	**Imposed ($\psi_S Q$)**	**Long Term Dead + Imposed ($G+\psi_L Q$)**
Supporting non-masonry partitions	Span/360 25 mm max.	-	L/500	Span/300 30 mm max.
Supporting masonry partitions	Span/360 25 mm max.	Span/1000 or; Span/750 if masonry articulated	L/500	Span/360 25 mm max.
Compactus Areas	Span/360 25 mm max.	Span/750 10 mm max.	L/500	Span/360 25 mm max.

Notes:

1. Incremental deflection is defined as long-term deflection minus short-term deflection, and occurs after the addition or attachment of the finish, wall or partition elements
2. Long-term creep, when present, needs to be included in assessing the long-term deflection of members that ate prone to creep.
3. For Roofs Systems, in addition to the requirements above, long-term deflections shall be controlled to prevent ponding and maintain falls to drainage outlets.

Deflection Limits Applicable to Steel Framed Roofs and Timber Framed Roofs:

Table 06: Proposed Deflection Criteria for Steel Framed and Timber Framed Roofs

Maximum Deflection Limits				
Type	**Dead (G)**	**Imposed ($\psi_s Q$)**	**Wind**	**Long Term Dead + Imposed ($G+\psi_L Q$)**
No ceilings with roof pitch > 3^O	Span/360	Span/250	Span/150	Span/150
No ceilings with roof pitch < 3^O	Span/500	Span/250	Span/150	Span/150
Lightweight ceilings with roof pitch > 3^O	Span/360 25 mm max.	Span/300	Span/250	Span/250
Lightweight ceilings with roof pitch < 3^O	Span/500	Span/300	Span/250	Span/250
Commercial plasterboard and acoustic ceilings	Span/500 25 mm max.	Span/600	Span/600	Span/250

Notes:

1. Ensure ponding does not occur and minimum pitch of roof is maintained for falls to drainage outlets.

Change proposal No. 4, Light Weight Steel Partition Framing Impact Load to DG21.06.05

Deflection design criteria in the EFSG are very prescriptive for some areas and others open to interpretation and could result in overdesigned structures.

Currently, a 2 kN impact load at mid-height is currently specified in the EFSG (Section 21.06.05). This item appears to be over-specified, and it is not clear if this applies to both load-bearing and non-load-bearing studs.

Typically, this is addressed to remove this requirement on a project-specific basis via a departure approval process.

Implication: overdesign as internal non-load bearing walls required, or alternatively additional secondary structural steelwork may be required depending on wall heights and location.

The recommendation is that this requirement is removed from EFSG, and that impact loads are added into the brief as a per-project basis if required.

Consideration to impact loading on walls inside sports halls/gymnasia is required.

The Design Guide Note provides the details of the proposed changes to Education Facilities Standards and Guidelines (EFSG) and/or design guidance for technical and project teams. If your projects are unable to meet these parameters, then please reach out to the Design and Infrastructure Standards (DaIS) team to assist. The DaIS team can help navigate achievable outcomes whilst informing ongoing development of SINSW projects.

Background: Vibration Limits

Expanded table below for the floor vibration limits which assigns a scenario to each limiting criteria and provides background or justification for recommendations.

Scenario	Learning Unit/Hub (Occupancy/Receiver)	Vibration Source	Number of Participants (Source)	RF Limit
1	General Learning Space (GLS) Library Hub Science Learning Hub Visual Arts Learning Hub Food + Textiles Learning Hub Health/PE Learning Hub Performing Arts Learning Hub Additional Learning Hubs Wood + Metal Technology Learning Hub	Single walker in the same space	1	8
2		Small groups of runners in the same space	1-3	60
3		Rhythmic activities in a neighbouring room	30	8
4		Rhythmic activities in the same room but separated (e.g. the other side of the room)	30	16
5	Administration Hub Staff Hub	Single walker in the same space	1	8
6		Unsynchronised groups of walkers (e.g. class moving as a group in corridors)	30	16
7	Gymnasium	Rhythmic activities – passive bystanders/spectators	30	55-100
8		Rhythmic activities – passive active/participants	30	120-200
9	Stairs	Stairs – heavy use (public)	30	32

General comments that apply to all scenarios:

1. RF limits are normally based on continuous vibration. This applies here except for small groups of runners (assumed to be intermittent) and to a lesser degree the scenarios for rhythmic activities and groups of walkers. This implies a degree of conservatism, but the commonly-applied RF=8 for office environments already allows for the fact that walking activities can be somewhere between continuous and intermittent.

2. Where RF limits are based on walking (e.g. the RF=8 base scenario), the assumption is that there is a single walker and not another scenario such as a larger group, or people running.

For each scenario listed, the following comments apply:

1. Scenario 1: RF=8 is a commonly applied limit for lively office spaces under normal conditions, where the criteria assumes a single walker. No specific criteria is readily available for schools, but a criteria equivalent to a lively/busy office or workshop would be appropriate. This considers that both children and adults (teachers/admin) exist in the same environment. Children are more likely to occupy the central zones in classrooms and will logically have a higher tolerance for liveliness, and this criterion is also appropriate for other scenarios where only adults are considered.

2. Scenario 2: Groups of runners are not normally considered in vibration design for the same criteria as for walking, and most design guides directly support the idea that floors are not expected to perform to the same level when the loading is more than a single walker. A safe limit would be 60, which is the lower range limit in Table C.1 ISO10137 for impulsive excitation events in office environments with several occurrences per day.

3. Scenario 3: Vibrations in a classroom may be generated by rhythmic activities in a neighbouring room, and those in the classroom may not be aware of their source. Hence the same acceptance criteria applies as per the base scenario.

4. Scenario 4: Same vibration receivers as scenario 3 but as there will be awareness that it is happening, there will be a higher tolerance for it than if it occurred in another separate room such that the activity could not be seen or heard. RF=16 is a safe limit for lightweight floors (as recommended in P354) even under normal conditions, i.e. in lieu of RF=8, so it would be suitable for this scenario.

5. Scenario 5: For office environments, a single walker is the same as the base scenario. RF=8 is acceptable for office environments and hence should apply to administration areas where only staff will typically be present.

6. Scenario 6: This is for administration offices mainly but also other classrooms which are affected by the vibrations from groups of children moving together but unsynchronised. For example, a class moving around the school together. RF=16 is recommended because:
    a. RF=16 is defensible for lightweight floors.
    b. This scenario may happen multiple times per day, and in some cases may be near continuous, so a limit is needed which allows for the fact that this scenario is not continuous, but nor is it rare.

c. While the dynamic loads from groups of walkers are higher than single walkers, the location of the receiver (i.e. in an administration office) is physically separated from the source(s), often by walls or other full-height partitions which will serve in part to reduce the vibration transmission.

7. Scenario 7: Participants in a rhythmic/jumping activity are unlikely to be bothered by the floor vibrating as they themselves are the source and are moving around. The limit here is somewhat nominal and based on an interpretation of the limits which are as high as 400 but apply to areas with low lighting and high levels of sound.

8. Scenario 8: People participating in rhythmic activities (2) have a high tolerance for vibrations as they themselves are jumping around. The RF which should apply here should be limited to 100. This is based on a rational interpretation of a number of different guides on this, but context is important. E.g. ISO10137 recommends RF=200 for passive bystanders in the midst of rhythmic activity from concerts, and P354 recommends RF=120 for nightclubs with low lighting and high levels of sound. Hence, 55-100 is given as a range if we can establish some context.

9. Scenario 9: As per ISO10137 guidance

Background: Imposed Floor Actions Classification

The imposed floor actions recommendations are based on discussions with SINSW with the aim of providing flexibility to the use of spaces, generally. This will ultimately allow for a reconfiguration of school layouts and room uses as the requirements change for each particular school. A blanket 3 kPa imposed floor action classification may result in some limitations compared to the Australian Standards for the particular function or use of some rooms, but an overall blanket load of 5 kPa imposed floor action would result in schools being overdesigned for most room uses. From discussions with SINSW, it is understood that it would be the preference to design to a 3 kPa imposed floor action generally and have the room fit outs and uses adhere to these limits.

A process is to be undertaken by SINSW to measure and quantify that the proposed room fit outs and uses can adhere to these limits.

Opportunities for further refinement have been marked with green in the following table:

1. Library Hub: Current recommendation is 4 kPa to adhere to AS 1170.1 requirements for a reading room with book storage. This may be reduced to 3 kPa through fitout-assessment and classfy as a “classroom”
2. Wood + Metal Technology Hub: Current recommendation is 5 kPa to adhere to AS 1170.1 requirements for a “workshop”. Opportunity to reduce to 3 kPa through fitout-assessment and classify as a “classroom”.

Recommendations that need to be verified by SINSW in the following table marked with red to ensure room use and fitout complies with the recommendation where deviation from AS 1170.1 has been adopted based on room definitions.

1. Food + Textiles Learning Hub: Current recommendation is 3 kPa to comply with “Communal Kitchens” definition within AS 1170.1. SINSW to verify that this is achievable and 5 kPa “commercial kitchen” action is not required.
2. Health/PE Learning Hub: Current recommendation is 3 kPa to comply with 3 kPa imposed floor action for a “classroom” to AS 1170.1. SINSW to verify that room use would be acceptable for this limit and a 5 kPa “Dance hall and studios” limit from AS 1170.1 is not required.
3. Performing Arts Learning Hub: Current recommendation is 3 kPa to comply with 3 kPa imposed floor action for a “classroom” to AS 1170.1. SINSW to verify that room use would be acceptable for this limit and a 5 kPa “Dance hall and studios” limit from AS 1170.1 is not required.

Expanded Imposed Floor Actions Classification

Learning Unit/Hub	Type of Activity	Specific Uses	Requirement (Uniformly Distributed Actions / Concentrated Actions)
General Learning Space (GLS)	C1	Classrooms	3 kPa / 2.7 kN
Administration Hub	B	Offices for General Use	3 kPa / 2.7 kN
Staff Hub	B	Offices for General Use	3 kPa / 2.7 kN
Library Hub	C1	Classrooms	3 kPa / 2.7 kN
	E	Reading rooms with book storage	4 kPa / 4.5 kN
Science Learning Hub	C1	Classrooms	3 kPa / 2.7 kN
Visual Arts Learning Hub	C1	Classrooms	3 kPa / 2.7 kN
Food + Textiles Learning Hub	C1	Classrooms	3 kPa / 2.7 kN
	B	Communal Kitchens	3 kPa / 2.7 kN
	B	Commercial/institutional kitchens	5 kPa / 4.5 kN
Health/PE Learning Hub	C1	Classrooms	3 kPa / 2.7 kN
	C4	Dance halls and studios	5 kPa / 3.6 kN
Performing Arts Learning Hub	C1	Classrooms	3 kPa / 2.7 kN
	C4	Dance halls and studios	5 kPa / 3.6 kN
Wood + Metal Technology Learning Hub	C1	Classrooms	3 kPa / 2.7 kN
	B	Workshops	5 kPa / 4.5 kN
Gymnasium	C4	Dance halls and studios, gymnasia	5 kPa / 3.6 kN