PART 19

BD 86/11

THE ASSESSMENT OF HIGHWAY BRIDGES AND STRUCTURES FOR THE EFFECTS OF SPECIAL TYPES GENERAL ORDER (STGO) AND SPECIAL ORDER (SO) VEHICLES

SUMMARY

This Standard gives criteria for the assessment of highway bridges and structures for the effects of Special Types General Order (STGO) and Special Order (SO) vehicles.

INSTRUCTIONS FOR USE


2. Insert BD 86/11 in Volume 3, Section 4, Part 19.

3. Please archive this sheet as appropriate.

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The Assessment of Highway Bridges and Structures for the Effects of Special Types General Order (STGO) and Special Order (SO) Vehicles

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November 2011
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PART 19

BD 86/11

THE ASSESSMENT OF HIGHWAY BRIDGES AND STRUCTURES FOR THE EFFECTS OF SPECIAL TYPES GENERAL ORDER (STGO) AND SPECIAL ORDER (SO) VEHICLES

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1. INTRODUCTION

General

1.1 This Standard gives requirements and guidance for the determination of Vehicle Ratings (3.46) and Reserve Factors (3.45) for highway bridges and structures. The Vehicle Ratings and Reserve Factors indicate the load carrying capacity of structures to support Special Type General Order (STGO) and Special Order (SO) vehicles. The need for assessment and the application of this standard should be determined in accordance with BD 101 (DMRB 3.4.22), and in consultation with the Overseeing Organisation.

1.2 Annex D may be used as a basis for checking the load carrying capacity of structures to support particular notified STGO vehicles which may need to cross the structure from time to time.

1.3 Road vehicles in the United Kingdom are categorised for regulatory purposes into three broad groups as given below:

1.3.1 Vehicles complying with The Road Vehicles Construction and Use (C&U) Regulations and Authorised Weight (AW) Regulations. This group includes cars, light goods vehicles, and rigid and articulated heavy goods vehicles up to a gross weight of 44 tonnes. These vehicles are covered by the C&U and AW Regulations (see reference 4) and are not subject to permit and notification requirements. For convenience, the term AW referred to hereinafter will be taken to include C&U. The effects of these AW vehicles are assessed in accordance with BD 21 (DMRB 3.4.3) when assessing highway bridges and structures.

1.3.2 Vehicles complying with The Road Vehicles (Authorisation of Special Types) General Order (STGO) Regulations. This group includes vehicles that do not comply with the AW Regulations such as those used for carrying or drawing abnormal indivisible loads (see Annex A). Vehicle operators are required to provide notification of vehicle movements in accordance with STGO Regulations.

1.3.3 Special Order (SO) Vehicles. This group includes vehicles that do not comply with the AW or STGO Regulations and is covered by Section 44 of the 1988 Road Traffic Act in England, Scotland and Wales. Vehicle operators are required to submit to the Overseeing Organisation an application for an individual Special Order authorising the movement of a SO vehicle. In Northern Ireland the equivalent vehicles are covered by Article 60 of the Road Traffic (Northern Ireland) Order 1995 and vehicle operators are required to submit applications for individual Special Orders authorising movements to Roads Service Headquarters, Network Development Branch.

1.4 Major changes in this version of BD 86:

(i) Introduction of SOV load models to assess the effects of SO vehicles.

(ii) Revised requirements for longitudinal loading.

(iii) Terminology amended to clarify the distinction between real vehicles and load models.

1.5 This Standard allows the assessment of load effects from STGO vehicles using SV load models, which produce more accurate results than the Type HB load model in BD 37 (DMRB 1.3). In general this should offer the following benefits:

(i) Attainment of higher load capacity ratings, particularly for structures with loaded lengths of less than 10m.

(ii) Flexibility to modify the Overload Factor, Dynamic Amplification Factor and associated Type HA loading.

(iii) Pre-assessment of structures on selected routes based on SOV load models allows rapid screening of the route for SO vehicle movement.

(iv) Consistent levels of safety for highway bridges and structures of different spans and for different STGO and SO vehicle movements.
1.6 For the purpose of this standard, unless real vehicles are specified, the effects of STGO and SO vehicles will be determined using the load models given in Chapter 3. If necessary, existing Type HB ratings may be converted to SV load model Reserve Factors in accordance with 3.48. New assessments for HB ratings are not encouraged, though will be permitted in addition to assessment for SV load models, subject to the agreement of the Overseeing Organisation, where they are needed for the continued operation of load management systems in use at the date of publication of this standard. However, the intention is that use of HB ratings will be phased out.

Scope

1.7 This Standard is intended for use, when carrying out assessment of highway bridges and structures, to assess the effects of STGO and SO vehicles in combination with the effects of AW vehicles and permanent loads.

1.8 The loads given in this Standard can be used for the assessment of bridges constructed of steel, concrete, wrought iron and cast iron, as well as the assessment of brick and stone masonry arches. It may be used for timber structures or stone slab bridge decks. It may also be used for the assessment of spandrel walls and buried structures. However, the Standard should not be used for the assessment of retaining walls, abutments and wing walls.

Mandatory Requirements

1.12 Sections of this Standard, which are mandatory requirements of the Overseeing Organisations, are highlighted by being contained within boxes. The remainder of the document contains advice and explanation, which is recommended for consideration.

Definitions

1.13 For the purpose of this Standard the following definitions apply:

(i) Abnormal Indivisible Load. A load which cannot, without undue expense or risk of damage, be divided into two or more loads for the purpose of carriage on roads.

(ii) Assessment. Inspection of a structure and determination of its load carrying capacity in terms of the appropriate vehicle or load model.

(iii) Assessment Loads. Loads determined for the assessment of the structure by applying the partial factors for load, $\gamma_{\text{Q}}$, to the nominal loads.

(iv) Assessment Resistance. The resistance determined by the application of a Condition Factor to the calculated resistance.

(v) AW Regulations. Authorised Weight (AW) Regulations governing the weights of normal vehicles using the highway.

(vi) AW Vehicles. Vehicles conforming to the Authorised Weight regulations, also refers to the AW vehicles given in BD 21 (DMRB 3.4.3).

(vii) Basic Axle Loads. Notified or specified axle loads excluding the effects of Overload Factor (OF) and Dynamic Amplification Factor (DAF).

(viii) Calculated Resistance. The capacity of the structure or element determined from its material strengths and section properties by applications of the partial factors for material strength, $\gamma_{\text{M}}$. 

Implementation

1.11 This Standard must be used, where specified, for the assessment of highway bridges and structures for the effects of STGO and SO vehicles. The specific structures and structural elements chosen for assessment must be agreed with the Overseeing Organisation.
Centrifugal Effects. Radial forces and changes to vertical live loading due to vehicles travelling in a horizontally curved path.

Condition Factor. A factor which accounts for deficiency in the integrity of the structure as defined in BD 21 (DMRB 3.4.3).

Dead Load. Loading due to the weight of the materials forming the structure or structural elements but excluding superimposed dead load materials.

Dynamic Amplification Factor. A factor to model the dynamic effects induced by the vehicles moving over a highway bridge or a structure (see 3.17).

Loaded Length. As defined in BD 37 (DMRB 1.3) and BD 21 (DMRB 3.4.3).

Notional Lane. A notional part of the carriageway assumed solely for the purpose of applying specified live loads.

Overload Factor. A factor to model the increase in axle loads above the nominal axle load arising from the overloading of vehicles and the uneven distribution of a vehicle’s total weight to its individual axles.

Reserve Factor. The ratio of the capacity of a structure available to support loading from a SV or a SOV load model to the load effect from a SV or SOV load model.

SO Vehicle. A Special Order vehicle (a real vehicle) that does not conform to the AW or STGO Regulations, but is covered by Section 44 of the 1988 Road Traffic Act. In Northern Ireland the equivalent vehicles are covered by Article 60 of the Road Traffic (Northern Ireland) Order 1995.

SOV Load Models. Load models intended to represent a range of real SO vehicles within the specified limits as defined in Table 3.1.

STGO Regulations. Special Types General Order (STGO) Regulations governing vehicles that do not conform to the AW Regulations for reasons of gross weight, height, length and/or axle weight and spacing configurations.

STGO Vehicle. A real vehicle conforming to the STGO Regulations.

Superimposed Dead Load. The weight of all materials imposing loads on the structure but which are not structural elements, such as surfacing, parapets, sandwich walls, service mains, ducts, miscellaneous street furniture.

SV Load Models. Load models intended to represent a range of real STGO vehicles as defined in 3.10.

Type HA Loading. A load model representing loading from AW vehicles as defined in BD 21 (DMRB 3.4.3).

Type HB Loading. A load model to represent loading from STGO vehicles as defined in BD 37 (DMRB 1.3).

Ultimate Limit State (ULS). Loss of equilibrium or collapse.

Vehicle Rating. The most onerous SV load model that can safely pass over the structure (i.e. the model which produces the smallest Reserve Factor greater than 1.0).
Symbols

1.14 The following symbols and abbreviations are used in this Standard.

- $b_l$: Notional lane width
- $DAF$: Dynamic Amplification Factor
- $DAF_{STGO}$: Dynamic Amplification Factor for STGO vehicle (see Annex D)
- $DAF_{SV}$: Dynamic Amplification Factor for SV load model (see Annex D)
- $M_{STGO}$: Mid-span bending moment due to STGO vehicles (see Annex D)
- $M_{SV}$: Mid-span bending moment due to SV load model (see Annex D)
- $N_{HB}$: Number of units in Type HB rating (see Annex C)
- $OF$: Overload Factor applied to each axle of a SV or SOV load model, STGO or SOV vehicle
- $OF_{STGO}$: Overload Factor applied to each axle of a STGO vehicle (see Annex D)
- $OF_{SV}$: Overload Factor applied to each axle of a SV load model (see Annex D)
- $Q_A^*$: Assessment loads
- $q_{la}$: Basic axle load of a SV or SOV load model, STGO or SOV vehicle (kN)
- $R_A^*$: Assessment resistance
- $S^*$: Load effect due to a SV or SOV, STGO or SOV vehicle
- $S_A^*$: Assessment load effect
- $S_D^*$: Assessment load effects due to dead and superimposed dead loads
- $S_{HA}^*$: Assessment load effect due to the associated Type HA (or AW vehicle loading)

$S_{HA(SV)}$: Unfactored load effect due to Type HA loading (or AW vehicle loading) associated with the SV load model (see Annexes C and D)

$S_{HA(STGO)}$: Unfactored load effect due to Type HA loading (or AW vehicle loading) associated with the STGO vehicle (see Annexes C and D)

$S_{HB45}$: Unfactored load effect due to 45 units of Type HB loading (see Annex C)

$S_{STGO}$: Unfactored load effect due to a STGO vehicle (see Annex D)

$S_{SV}$: Unfactored load effect due to a SV load model (see Annex D)

$W_{STGO}$: Gross weight of a STGO vehicle (see Annex D)

$W_{SV}$: Gross weight of a SV load model (see Annex D)

$\Psi_{SV}$: Reserve Factor against a SV load model with the associated Type HA loading (or AW vehicle loading)

$\Psi_{SV}^*$: Reserve Factor against a SV load model without the associated Type HA loading (or AW vehicle loading)

$\Psi_{SOV}$: Reserve Factor against a SOV load model with the associated Type HA loading (or AW vehicle loading)

$\Psi_{SOV}^*$: Reserve Factor against a SOV model without the associated Type HA loading (or AW vehicle loading)

$\gamma_{IL}$: Partial factor for load

$\gamma_{IL}$: Partial factor for load effect

$\gamma_{HB45-SV}$: Conversion Factor for Reserve Factor from 45 units of Type HB loading to an equivalent SV load model (see Annex C)
2. OBJECTIVES AND PROCEDURES

General

2.1 The objective of assessment is to determine the vehicle loading that a given structure can carry such that, with a reasonable probability, it will not suffer serious damage endangering any persons or property on or near the structure.

2.2 The procedures for the assessment of highway bridges and structures must follow the provisions of BD 21 (DMRB 3.4.3) with additional requirements given or as specified otherwise in this Standard.

2.4 In composite and steel bridges there are a number of cases where ULS checks are not required because ULS and Serviceability Limit State (SLS) criteria are closely related and it is known that SLS will govern. In these cases the checking for ULS only would be unsafe and SLS criteria must be checked.

2.5 Reference should therefore be made to:

(i) BD 56 (DMRB 3.4.11) – for stiffened flanges subject to local bending when local bending stresses are neglected at ULS.

(ii) BD 61 (DMRB 3.4.16) – for assessment of shear connection and longitudinal shear in cased and filler beams.

(iii) BA 16 (DMRB 3.4.17) – where cased and filler beams are assessed using BA 16 and the ‘yield moment’ is used as the ultimate moment, the interface shear should be assessed at SLS.

Limit States

2.3 This Standard generally adopts the limit state format as described in BD 21 (DMRB 3.4.3). The limit state to be adopted for this Standard is the Ultimate Limit State (ULS), using appropriate partial factors. However, for masonry arch bridges and cast iron bridges alternative assessment methods must be adopted in accordance with BD 21 (DMRB 3.4.3).
Assessment Loads

2.6 The assessment loads, $Q_\text{a,*}$, must be as defined in BD 21 (DMRB 3.4.3). The $\gamma_\text{a}$ values for SV load models, STGO vehicles, SOV load models and SO vehicles and associated Type HA loading (or AW vehicle loading) must be taken from Table 2.1, except for arch bridges (see 3.35).

<table>
<thead>
<tr>
<th>Loading</th>
<th>$\gamma_\text{a}$</th>
<th>Cast Iron Bridges</th>
<th>Other Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SV load model</td>
<td>1.0</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>STGO vehicle</td>
<td>1.0</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>SOV load model</td>
<td>1.0</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>SO vehicle</td>
<td>1.0</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>Associated Type HA loading (or AW vehicle loading) when combined with</td>
<td>1.0</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>SV load model, STGO vehicle, SOV load model or SO vehicle</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2.1: Values of $\gamma_\text{a}$ – Partial Factor for Live Loads at ULS

2.7 $\gamma_\text{a}$ at SLS must be taken as 1.0 for all live loads in Table 2.1.

Load Combinations

2.8 Dead and superimposed dead loads must be combined with live loads using the factors given in 2.6.

2.9 When other loads not specified in this document are considered necessary for assessment purposes, reference must be made to BD 37 (DMRB 1.3) for the details of these loads, the appropriate load combinations and their respective $\gamma_\text{a}$ values (except for cast iron bridges, where the values of $\gamma_\text{a}$ must be taken as 1.0). However, for load combinations 2 and 3, $\gamma_\text{a}$ for SV, STGO, SOV or SO loads must be taken as 1.0.

Assessment Load Effects

2.10 The assessment load effects, $S_{\text{a,*}}$, must be as defined in BD 21 (DMRB 3.4.3).

Verification of Structural Adequacy

2.11 Structures must be subject to verification of structural adequacy in accordance with the requirements and guidance given in BD 21 (DMRB 3.4.3).
3. LOADING

General

3.1 The Vehicle Ratings and Reserve Factors of highway bridges and structures must be determined by the loading requirements given in this Chapter. Assessment loading will generally be limited to the application of dead and superimposed dead loads, a SV load model, STGO vehicle, SOV load model or SO vehicle and associated Type HA loading (or AW vehicle loading). All loads specified in this Chapter are nominal loads unless otherwise stated and must be multiplied by the appropriate partial factors given in 2.6.

3.2 When the carriageway on the bridge is horizontally curved, the structure must be assessed for the live loading requirements given in this chapter and, in addition, a separate assessment for centrifugal effects is required in accordance with 3.33.

Nominal Assessment STGO and SO Loading

General

3.5 Assessment must be carried out for the effects of the SV load models (see 3.10).

3.6 Where required by the Overseeing Organisation, assessment may also be carried out for the effects of:

(i) specific STGO vehicles (see 3.11);
(ii) SOV load models (see 3.12);
(iii) specific SO vehicles (see 3.13);
(iv) type HB loading.

The limitations of SV and SOV load models are given in Annex B9.

Notional Lane Width ($b_1$)

3.3 The carriageway must be divided into notional lanes in accordance with BD 21 (DMRB 3.4.3).

Nominal Dead Load and Nominal Superimposed Dead Load

3.4 The nominal dead load and nominal superimposed dead load must be taken as defined in BD 21 (DMRB 3.4.3). Where available, these loads must be calculated based on the measured dimensions and densities of materials.

3.7 For loaded lengths of up to 50m the following loads must be applied, as appropriate to the load model:

(i) Nominal axle loads: Basic axle loads for SV load models (3.10) or for SOV load models (3.12) multiplied by the appropriate Overload Factor (3.16) and Dynamic Amplification Factor (3.17).
(ii) Associated Type HA loading or AW vehicle loading (3.18 to 3.31).

3.8 For loaded lengths in excess of 50m, advice must be sought from the Overseeing Organisation.

3.9 Accidental wheel/vehicle loading and footway loading are not required when assessing for SV load models or SOV load models.
3.10 Assessment for STGO Vehicles Using SV Load Models

3.10.1 The following five load models simulate the vertical effects of different types of STGO vehicles (see Annex A) with basic axle weights not exceeding 16.5 tonnes and military tank transporter vehicles with basic axle weights of up to 25 tonnes. They do not describe actual vehicles, but have been chosen so that their effects, including dynamic amplification, represent the extreme effects that could be induced by the actual STGO vehicles. The axle weight and spacing of SV vehicles are therefore close to, but not exactly equal to, the allowable limits of the STGO Regulations. The Type HA loading covers the effects of STGO Category 1 vehicles with a maximum gross vehicle weight of 46 tonnes.

3.10.2 SV80. The SV80 load model is intended to model the effects of STGO Category 2 vehicles with a maximum gross vehicle weight of 80 tonnes and a maximum basic axle load of 12.5 tonnes. Figure 3.1 shows the basic axle loads, plan and axle configuration. The spacing of 5.0m and 9.0m between the two bogies need be checked only for load effects with two or more peaks in the influence line/surface for loaded lengths of greater than 12m.

![SV80 Load Model](image)

**Figure 3.1: SV80 Load Model**

3.10.3 SV100. The SV100 load model is intended to model the effects of STGO Category 3 vehicles with a maximum gross vehicle weight of 100 tonnes and a maximum basic axle load of 16.5 tonnes. Figure 3.2 shows the basic axle loads, plan and axle configuration. This model is critical for loaded lengths typically less than 10m. The spacing of 5.0m and 9.0m between the two bogies need be checked only for load effects with two or more peaks in the influence line/surface for loaded lengths of greater than 12m.
3.10.4 **SV 150.** The SV150 load model is intended to model the effects of STGO Category 3 vehicles with a maximum gross vehicle weight of 150 tonnes and a maximum basic axle load of 16.5 tonnes. Figure 3.3 shows the basic axle loads, plan and axle configuration. The spacing of 5.0m and 9.0m between the two bogies need be checked only for load effects with two or more peaks in the influence line/surface for loaded lengths of greater than 17m.
3.10.5 SV-Train. The SV-Train load model is intended to model the effects of a single locomotive pulling a Category 3 trailer. Figure 3.4 shows the basic axle loads, plan and axle configuration. This model generally governs for all structures with loaded lengths greater than 10m. The spacing of 5.0m and 9.0m between the two bogies need be checked only for load effects with two or more peaks in the influence line/surface for loaded lengths of greater than 40m.
3.10.6 **SV-TT.** The SV-TT load model is intended to model the effects of military tank transporter vehicles with a maximum basic axle load of 25 tonnes. Figure 3.5 shows the basic axle loads, plan and axle configuration. This model is only critical for loaded lengths of typically less than 5m.

![Figure 3.5: SV-TT Load Model](image)

### 3.11 STGO Vehicles Outside the Scope of SV Load Models

3.11.1 For a specific STGO vehicle that is outside the scope of the SV load models defined in 3.10, the vehicle must be assessed initially by comparing its load effect against the load effect from a SV load model with the associated Reserve Factor using one or more influence lines considered most appropriate for the structure. The procedures given in D.3 to D.6 may be used for this purpose.

3.11.2 In 3.11.1, if the load effect from the vehicle exceeds the load effect from the SV load model, then the structure must be assessed directly using this vehicle, with the values of DAF, OF, $\gamma_{fl}$, and $\gamma_{at}$ applied in the same way as they are for SV load models.

3.11.3 For loaded lengths of up to 50m, associated Type HA loading or AW vehicle loading (3.18 – 3.31) must be applied. For loaded lengths in excess of 50m, advice must be sought from the Overseeing Organisation.
3.12 Assessment for SO Vehicles Using SOV Load Models

3.12.1 The following four SOV load models simulate vertical effects of Special Order (SO) vehicles with trailer weights limited to:

(i) SOV-250 – Maximum total weight of SO trailer units up to 250 tonnes;
(ii) SOV-350 – Maximum total weight of SO trailer units up to 350 tonnes;
(iii) SOV-450 – Maximum total weight of SO trailer units up to 450 tonnes;
(iv) SOV-600 – Maximum total weight of SO trailer units up to 600 tonnes.

3.12.2 The load models do not describe actual vehicles but have been chosen so that their effects, combined with Dynamic Amplification Factor, represent the extreme effects that could be induced by real Special Order vehicles.

3.12.3 The choice of the particular SOV load model for the assessment of structures on motorways, trunk roads and other minor roads must be agreed with the Overseeing Organisation.

3.12.4 The SOV load models are applicable to Special Order vehicles within the axle load and configuration limits defined in Table 3.1.

<table>
<thead>
<tr>
<th>Configuration parameter</th>
<th>Limiting Value</th>
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<tbody>
<tr>
<td>Tractor</td>
<td></td>
</tr>
<tr>
<td>Maximum weight of the front axle in a 4-axle tractor</td>
<td>10 tonnes</td>
</tr>
<tr>
<td>Maximum weight of any of the rear three axles in a 4-axle tractor or any axle in a 3-axle tractor</td>
<td>16.5 tonnes</td>
</tr>
<tr>
<td>Minimum spacing between the 1st and 2nd axle</td>
<td>1.85m</td>
</tr>
<tr>
<td>Minimum spacing between the 2nd and 3rd axle (only for a 4-axle tractor)</td>
<td>1.35m</td>
</tr>
<tr>
<td>Minimum spacing between the two rear axles</td>
<td>1.35m</td>
</tr>
<tr>
<td>Trailer</td>
<td></td>
</tr>
<tr>
<td>Maximum axle weight</td>
<td>22.5 tonnes</td>
</tr>
<tr>
<td>Minimum spacing between trailer axles</td>
<td>1.5m</td>
</tr>
<tr>
<td>Minimum spacing between rear axle of the tractor and the front axle of the trailer (or rear axle of trailer and front axle of tractor)</td>
<td>5.0m</td>
</tr>
<tr>
<td>Maximum spacing between the two trailer units</td>
<td>40.0m</td>
</tr>
<tr>
<td>Minimum outside track of trailer axles</td>
<td>2.75m</td>
</tr>
</tbody>
</table>

Table 3.1: Limits on SO Vehicle Configuration Parameters Applicable for SOV Load Models

Basic Axle Load and Configuration of SOV Load Models

3.12.5 The longitudinal configuration of the four load models are shown in Figure 3.6. The standard configuration has a trailer with two bogies and two tractors; one pulling and one pushing. However, on structures located on a stretch of road with a gradient steeper than 1 in 25, six tractor units, in any combination of pulling and pushing that produces the worst effect, must be considered for assessment.
Note to figures (a) to (d): For simplicity, not all the axles on the trailers are shown. The actual number of axles of trailer bogie should be that stated above the figure.

**Figure 3.6: Basic Longitudinal Configuration of SOV Load Models**
3.12.6 The lateral wheel arrangement for the trailer axles of all the SOV load models is shown in Figure 3.7. All the wheels are of equal weight. The tractor axles of the load models have two wheels, each of equal weight, with outside track and overall width of 3.0m.

![Figure 3.7: Lateral Wheel Arrangement for Trailer Axles of all SOV Load Models](image)

3.13 SO Vehicles Outside the Scope of SOV Load Models

3.13.1 For a specific SO vehicle that is outside the scope of the SOV load models defined in 3.12, the vehicle must be assessed initially by comparing its load effect against the load effect from a SOV load model with the associated Reserve Factor using one or more influence lines considered most appropriate for the structure. The procedures given in D.3 to D.6 may be used for this purpose, substituting ‘SOV’ for ‘SV’ and ‘SO’ for ‘STGO’ as appropriate.

3.13.2 In 3.13.1, if the load effect from the vehicle exceeds the load effect from the SOV load model, then the structure must be assessed directly using this vehicle, with the values of DAF, OF, γ₁₁ and γ₁₂ applied in the same way as they are for SOV load models.

3.13.3 For loaded lengths of up to 50m, associated Type HA loading or AW vehicle loading (3.18 – 3.31) must be applied. For loaded lengths in excess of 50m, advice must be sought from the Overseeing Organisation.

Wheel Contact Areas

3.14 The wheel loads for SV load models must be uniformly distributed over a square or rectangular contact area as shown in Figures 3.1 to 3.5. The wheel loads for SOV load models must be uniformly distributed over a square contact area of 0.35m x 0.35m as shown in Figure 3.7. For specific STGO or SO vehicles the contact areas must be as given in the notifications by the hauliers. In the absence of such information, the load from each wheel of the vehicle may be taken as uniformly distributed over a square contact area of 0.35m x 0.35m.
Dispersal of Wheel Loads

3.15 The dispersal of wheel loads through surfacing, filling material and structural concrete slabs must follow the procedures given in BD 21 (DMRB 3.4.3). This also applies to trough decks and masonry arches.

Overload Factor

3.16 The Overload Factor models the overloading of SV or SOV load models in excess of the gross weight and axle weights notified by the hauliers to highway authorities. The Overload Factor (OF) must be taken as 1.2 for the worst critical axle and 1.1 for all other axles of SV or SOV load models.

Dynamic Amplification Factor

3.17 The Dynamic Amplification Factor (DAF) for each axle of SV or SOV load model must be calculated as given below:

\[
DAF = \left[ 1.7 \times \left( \frac{q_{ka}}{10} \right)^{-0.15} \right] \geq 1.05 \tag{3.1}
\]

where \( q_{ka} \) is the basic axle load in kN. Note that the DAF values could be different for the different axles depending on their loads. The variation of DAF with basic axle load is illustrated in Figure 3.8.

![Figure 3.8: Dynamic Amplification Factor as a Function of Basic Axle Load \( q_{ka} \)](image)
Associated Type HA Loading or AW Vehicle Loading

3.18 The effects of normal vehicles (those that conform to the AW Regulations) associated with SV or SOV load models, and specific STGO or SO vehicles must be represented by the associated Type HA loading or AW vehicle loading in accordance with BD 21 (DMRB 3.4.3).

3.19 Separate assessments are not required for single wheel loads or single axle loads from AW vehicle loading associated with an SV or SOV load model.

Application of SV or SOV Load Models and Associated Type HA Loading or AW Vehicle Loading

3.20 SV or SOV load models and associated Type HA loading or AW vehicle loading must be combined and applied as follows:

(i) Associated Type HA loading must be applied to the notional lanes of the carriageway as 2.5m wide strips in accordance with BD 21 (DMRB 3.4.3). Where appropriate, the Type HA loading can be replaced by the AW vehicle loading given in BD 21 (DMRB 3.4.3).

(ii) Only one SV or SOV load model must be considered on any one superstructure.

3.21 The SV or SOV load model can be placed at any transverse position on the carriageway, either wholly within one notional lane or straddling between two adjacent lanes, with its side parallel to the kerb. The SV or SOV load model must be placed at the most unfavourable position transversely and longitudinally over the loaded length, in order to produce the most severe load effect at the section being considered.

3.22 The design load effects must be determined from the maximum of the two cases:

(i) SV or SOV load model moving at ‘normal’ speed; and

(ii) SV or SOV load model moving at ‘low’ speed (< 10 mph).

3.23 Where the SV or SOV load model lies fully within a notional lane and is moving at ‘normal’ speed the associated Type HA loading or AW vehicle loading must not be applied within 25 metres from the centre of outer axles (front and rear) of the SV or SOV load model in that lane. This is illustrated in Figure 3.9(a). The Dynamic Amplification Factor must be taken as given in 3.17.

3.24 Where the SV or SOV load model lies fully within a notional lane and is moving at ‘low’ speed the associated Type HA loading or AW vehicle loading must not be applied within 5 metres from the centre of outer axles (front and rear) of the SV or SOV load model in that lane. This is illustrated in Figure 3.9(b). The Dynamic Amplification Factor must be taken as 1.0.

3.25 The remainder of the adverse areas within the loaded length in the lane occupied by the SV or SOV load model must be loaded with associated Type HA UDL (uniformly distributed load) only; Type HA KEL (knife edge load) must be omitted. The intensity of the Type HA UDL must be based on the total loaded length of the adverse areas within the length and not the reduced length over which the Type HA UDL is applied. This is illustrated in Figures 3.9 (a) and (b).
Figure 3.9: Typical Application of Type SV or Type SOV and Associated Loading when the SV or SOV Load Model Lies Fully Within a Notional Lane

Note: Type HA loading can be replaced where appropriate by AW vehicle loading

Figure 3.10: Typical Application of Type SV or Type SOV and Associated Type HA Loading when the SV or SOV Load Model Straddles Two Adjacent Notional Lanes

Note: Type HA loading can be replaced where appropriate by AW vehicle loading
3.26 Where the SV or SOV load model lies partially within a notional lane and the remaining width of the lane, measured from the side of the SV or SOV load model to the far edge of the notional lane, is less than 2.5m (Figure 3.10(a)), the associated Type HA UDL must not be applied to that lane within 25m of the centre of the outer axles (front and rear) of the SV or SOV load model, for the ‘normal’ speed case. For the ‘low’ speed case, the Type HA UDL must not be applied within 5m of the centre of the outer axles (front and rear) of the SV or SOV load model.

3.27 Where the SV or the SOV load model lies partially within a notional lane and the remaining width of the lane, measured from the side of the SV or SOV load model to the far edge of the notional lane, is greater or equal to 2.5m, the Type HA UDL loading in that lane must remain (Figure 3.10(b)) but the Type HA KEL must be omitted.

3.28 On the remaining lanes not occupied by the SV or SOV load model, the associated Type HA loading (UDL and KEL) or AW vehicle loading with appropriate Lane Factors must be applied in accordance with BD 21 (DMRB 3.4.3). This is illustrated in Figures 3.9(a) and (b) and 3.10(a) and (b) for typical configurations of Type HA loading in combination with Type SV or Type SOV loading.

3.29 All of the notional lanes and their corresponding Lane Factors are interchangeable for producing the most severe load effect.

3.30 Figures 3.9 and 3.10 must also be applied to assessments based on specific STGO and SO vehicles.

Transverse Members

3.31 As an exception to 3.20 to 3.30, for transverse cantilever slabs, slabs supported on all four sides, cross-girders and slabs spanning transversely (including skew slabs with significant transverse action), the associated Type HA loading must be replaced with the AW vehicle loading and applied as a single vehicle or convoy of vehicles in accordance with Annex D of BD 21 (DMRB 3.4.3). The travelling speed of SV or SOV load models may be different from that of the associated AW vehicles. However, if a convoy of vehicles is assumed for the associated AW vehicles, SV or SOV load models should only be considered at the ‘low’ speed case.

3.32 Transverse trough decks must be assessed for SV or SOV load models considering loading from all the axles, including OF and DAF. The associated Type HA loads must be assessed on the basis of a single axle and/or single wheel load of AW vehicles per lane with trough enhancement factors as given in BD 21 (DMRB 3.4.3).

Centrifugal Effects

3.33 The vertical effects arising from centrifugal forces on horizontally curved carriageways must be determined for SV loading using the method given in BD 21 (DMRB 3.4.3) assuming speeds practicable for real STGO vehicles in the range between 30 and 50mph. The centrifugal effects of SOV loading may be ignored.

Longitudinal Loading

3.34 The longitudinal loading (see reference 5) must be taken as the most severe of the braking or traction force determined as follows:

For SO or SOV Load Models

3.34.1 Braking force of 50% of the basic axle loads for the SV80 load model; 40% for SV100; 25% for SV150 and 20% for SV-Train and all SOV load models, applied to each corresponding axle of the SV or SOV Load Model.

3.34.2 Acceleration force of 10% of the gross weight for all SV and SOV load models distributed between the axles in the same proportion as the vertical loads.
For a Specific STGO Vehicle

3.34.3 The longitudinal load must be taken from whichever of the following produces the most severe effect:

(i) a braking force of 50% of the gross weight for a category 2 STGO vehicle; 40% for STGO category 3 vehicle up to a gross weight of 100 tonnes and 25% for STGO vehicle over 100 tonnes gross weight, distributed proportionally to the loads carried by the individual braking axles;

(ii) a traction force of 10% of the gross weight of the STGO vehicle distributed proportionally to the loads carried by the individual driving axles.

For a Specific SO Vehicle

3.34.4 The braking load must not be considered for assessment if the vehicle is controlled (i.e. the vehicle is escorted). Where the SO vehicle is not escorted, the longitudinal load must be taken from whichever of the following produces the most severe effect:

(i) a braking force of 20% of the gross weight of the SO vehicle distributed proportionally to the loads carried by the individual braking axles;

(ii) a traction force of 10% of the gross weight of the SO vehicle distributed proportionally to the loads carried by the individual driving axles.

Masonry Arches

3.35 As an exception to 3.20 to 3.30, when alternative methods to MEXE (see BD 21 (DMRB 3.4.3) and BA 16 (DMRB 3.4.4)) are used for the assessment of masonry arches, the associated Type HA loading must be replaced with the loading from single, double and triple axles of AW vehicles given in BD 21 (DMRB 3.4.3) with the corresponding conversion factors to account for axle lift-off. For arch spans greater than 20m, a separate assessment must also be made with the Type HA UDL and KEL loading.

3.36 Where conditions on an arch bridge are likely to cause lift-off (see BA 16 (DMRB 3.4)), a triple-axle bogie must be assumed within the SV or SOV load model comprising the worst effective axle and the following two axles. For the case of a SV or SOV load model travelling at ‘normal’ speed, a lift-off factor of 1.2 must be applied to the leading axle and a factor of 0.8 to the trailing axle of this bogie. No lift-off must be applied to the remaining axles. The lift-off requirement must not apply to SV or SOV load models for the ‘low’ speed case.

3.37 Alternative analysis to the MEXE method must be used where the geometry of the arch is such that three or more axles of the SV or SOV load model can be applied in half of the span whilst the remaining half is not loaded.

3.38 The factors of safety $\gamma_{st}$ for the assessment of masonry arches when using alternative methods to MEXE must be 2.0 for SV or SOV loading and associated Type HA loading or AW vehicle loading. In addition, the effects of OF and DAF must be included.
Buried Structures

3.39 For buried concrete box type structures (cover greater than 0.6m), the associated Type HA loading must be replaced with AW vehicle loading in accordance with BA 55 (DMRB 3.4.9). The wheel loads must be dispersed from the carriageway to the top of the buried structure in accordance with BA 55 (DMRB 3.4.9). Dynamic effects for STGO, SO and AW vehicles or their respective load models may be reduced for buried structures in accordance with BA 55 (DMRB 3.4.9).

Choice of SV and SOV Load Models for Assessment

3.40 The Assessment must be carried out for all SV load models and for selected (as agreed with the Overseeing Organisation) SOV load models. For all load models assessed, Reserve Factors must be determined and recorded in the Overseeing Organisation’s bridge management system.

3.41 By reference to Figures C.7 to C.12 of Annex C, ascertain the governing SV load models for the loaded length and the load effect being considered, and assess the structure for this load model. The following is tentative guidance and should be verified by the assessing engineer:

(i) For loaded lengths of less than 5m, where heavy axle loads dominate, the SV-TT load model generally gives the most onerous loading.

(ii) For loaded lengths of between 5m and 10m, the SV 100 load model generally governs.

(iii) For loaded lengths of greater than 10m, the SV-Train load model generally governs.

(iv) If the Reserve Factor is greater than or equal to 1.0 for the above appropriate load case, other SV load models are likely to be less critical.

3.42 For structures where the capacity is less than the load effects from the above load models, the structure can generally be assessed for SV load models in the following order:

(i) **SV-Train.** When a structure can sustain the SV-Train, it can generally sustain the SV-150, SV-100 (for spans greater than 10m) and SV-80 load models.

(ii) **SV-150 load model.** When a structure can sustain the SV-150 load model, it can generally sustain the SV-100 (for spans greater than 10m) and SV-80 models.

(iii) **SV-100 model.** When a structure can sustain the SV-100 model, it can generally sustain the SV-80 load model.

3.43 The assessments should initially be carried out with the associated Type HA loading (or AW vehicle loading). If the Reserve Factor is greater than or equal to 1.0 for any SV load model, assessment without the associated Type HA loading (or AW vehicle loading) is not necessary.

3.44 For short span structures (less than 20m), the normal speed case will generally govern, due to the application of the Dynamic Amplification Factor. For the SV-Train, only the normal speed case need be considered.

**Reserve Factors**

3.45 For each SV or SOV load model considered, a Reserve Factor, $\Psi_{SV}$ or $\Psi_{SOV}$, must be established. This is defined as the factor on the assessment SV or SOV load required to reach the first failure. For example, where elastic methods are used and there is no interaction between load effects, the Reserve Factor $\Psi_{SV}$ or $\Psi_{SOV}$ can be calculated as follows:

**With Associated Type HA Loading (or AW vehicle loading)**

$$\Psi_{SV} \text{ or } \Psi_{SOV} = \frac{R_A^* - (S_D^* + S_HA^*)}{S^*} \quad (3.2)$$

**Without Associated Type HA Loading (or AW vehicle loading)**

$$\Psi_{SV}^* \text{ or } \Psi_{SOV}^* = \frac{R_A^* - S_D^*}{S^*} \quad (3.3)$$
where:

- $R_d^*$ assessment resistance (flexure, shear, etc.)
- $S_d^*$ assessment load effect due to combined dead and superimposed dead loads
- $S_{ld}^*$ assessment load effect due to the associated Type HA loading (or AW vehicle loading)
- S* assessment load effect due to the SV or SOV load model

### Vehicle Rating

3.46 The Reserve Factors for each SV and SOV load model may be given in a tabular form similar to that shown in Table 3.2. Certain types of structures (cast iron, masonry arches, for example) may not yield a directly comparable Reserve Factor, and their ability to sustain vehicles needs to be considered separately for each load case.

3.47 The Vehicle Rating for a structure must be taken as the most onerous SV and SOV load model that can safely pass over the structure (i.e. the load model with the smallest Reserve Factor $\Psi_{sv}$ and $\Psi_{sov}$ greater than or equal to 1.0).

### Type HB-to-SV Conversion Charts

3.48 Where existing Type HB ratings for highway bridges and structures are available and the Overseeing Organisation is satisfied with the manner in which these have been derived, the corresponding Reserve Factors for SV load models can be obtained approximately using the Type HB-to-SV Conversion Charts given in Annex C.

### BE-AIL-to-SV Conversion Charts

3.49 Similar conversion charts have been developed for converting the BE-AIL (a range of vehicles traditionally used during design to cater for special order vehicles) and Heavy Load Grid vehicle capacities into equivalent SOV reserve factors. These charts will be used by the Overseeing Organisation’s team responsible for managing Special Order load movements.
Vehicle Assessment

Structure Name: 
Structure Key: 
Vehicle Type+: 
Vehicle Speed+: Normal/Low 
Method of Assessment+: Type HB-SV Chart/Line Beam/Grillage/FEM/Other (state) 
Limit State+: SLS/ULS 
+ Delete as applicable

<table>
<thead>
<tr>
<th>Element</th>
<th>Location on Structure</th>
<th>Load Effect</th>
<th>$R^*_A$</th>
<th>$S^*$</th>
<th>$S^*_D$</th>
<th>$S^*_H$</th>
<th>$\Psi^*_S$</th>
<th>$\Psi^*_SOV$</th>
<th>$\Psi^*_S$</th>
<th>$\Psi^*_SOV$</th>
</tr>
</thead>
</table>

Table 3.2: Reserve Factors
4. REFERENCES

The following documents are referred to in the text of this Standard:


3. The following is a list of documents in the Design Manual for Roads and Bridges to which reference is made in this Standard:

   BD 37 Loads for Highway Bridges (DMRB 1.3)
   BD 21 The Assessment of Highway Bridges and Structures (DMRB 3.4.3)
   BA 16 The Assessment of Highway Bridges and Structures (DMRB 3.4.3)
   BA 55 The Assessment of Bridge Substructures and Foundations, Retaining Walls and Buried Structures (DMRB 3.4.9)
   BD 56 The Assessment of Steel Highway Bridges and Structures (DMRB 3.4.11)
   BD 61 The Assessment of Composite Highway Bridges (DMRB 3.4.16)
   BD 101 Structural Review and Assessment of Highway Structures (DMRB 3.4.22)

4. The following is a list of Statutory Instruments to which reference is made in this Standard:

   The Road Vehicles (Construction and Use) (Amendment) (No.7) Regulations 1998 (SI 1998 No.3112)
   The Road Vehicles (Authorised Weight) Regulations 1998 (SI 1998 No.3111)
   The Road Vehicles (Authorisation of Special Types) General Order 2003 (SI 2003 No.1998)

   The Motor Vehicles (Construction and Use) Regulations (Northern Ireland) 1999
   The Motor Vehicles (Authorisation of Special Types) Order (Northern Ireland) 1997 (SR 1997/109) as amended
   The Motor Vehicles (Authorised Weight) Regulations (Northern Ireland) 1999 as amended


5. ENQUIRIES

All technical enquiries or comments on this Standard should be sent in writing as appropriate to:

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Director of Engineering
The Department for Regional Development
Roads Service
Clarence Court
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Belfast BT2 8GB
R J M CAIRNS Director of Engineering
ANNEX A  STGO VEHICLE CATEGORIES

A1. Introduction

The maximum gross and axle weights allowable under Schedule 1 of the STGO Regulations are briefly described below. In Northern Ireland the article number is different from the equivalent legislation in Great Britain. For full details, including other vehicles such as Engineering Plant and Military Vehicles, the Regulations should be consulted.

A2. Abnormal Indivisible Load Vehicles

These may consist of either Abnormal Indivisible Load Vehicles (AILVs) or an AILV and Trailer (AILV-combination). They are used for carrying or for drawing abnormal indivisible loads (e.g. industrial plant) up to a maximum weight of 150,000 kg and are covered by Schedule 1 of the STGO Regulations. These vehicles are grouped into the three weight Categories given below.

(a) Category 1 AILVs and AILV-combinations

AILVs and AILV-combinations in this category will have a minimum of five axles and must comply with the AW or C&U Regulations with regard to maximum vehicle weight, axle weights and spacing. The total weight of a Category 1 AILV-combination carrying a load must not exceed 46,000 kilograms. However, vehicles with six or more axles that comply in all other respects with the AW Regulations that apply to a vehicle combination of 44,000 kilograms, the gross weight can be up to 50,000 kilograms. The Type HA loading covers the effects of these vehicles and hence these are not specifically included in the Type SV loading.

(b) Category 2 AILVs and AILV combinations

Vehicles in this category must have a minimum of six axles and the spacing between any two adjacent axles must not be less than 1m. Total weight of AILV or AILV-combination carrying a load must not exceed 80,000 kilograms. The weight, in kilograms, of AILV or AILV-combination must be calculated as $D \times 7,500$ and then round up to the nearest 10 kilograms, where $D$ is taken as the distance, in metres, between the foremost axle and the rearmost axle of the AILV carrying the load or in the case of an articulated AILV-combination, the kingpin and the rearmost axle on the semi-trailer. Maximum permitted values of axle weight and minimum axle spacing are shown in Table A.1.

Where the axles are in two or more groups and adjacent axes of different groups are more than 2m apart, then the total weight from all axles in any one group must not exceed 50 tonnes.

(c) Category 3 AILVs and AILV-combinations

Vehicles in this category must have a minimum of six axles and the spacing between any two adjacent axles must not be less than 1m. Total weight of a Category 3 AILV or AILV-combination carrying a load must not exceed 150,000 kilograms. The weight, in kilograms, of AILV or AILV-combination must be calculated as $D \times 12,500$ and then round up to the nearest 10 kilograms, where $D$ is taken as the distance, in metres, between the foremost axle and the rearmost axle of the AILV carrying the load or in the case of an articulated AILV-combination, the kingpin and the rearmost axle on the semi-trailer. Maximum permitted values of axle weight and minimum axle spacing are shown in Table A.2.

Where the axles are in two or more groups and adjacent axes of different groups are more than 1.5m apart, then the total weight from all axles in any one group must not exceed 100,000 kilograms. This will be limited to 90,000 kilograms for a group if the spacing between adjacent axles for that group is less than 1.35m.

<table>
<thead>
<tr>
<th>Spacing between any two adjacent axles (m)</th>
<th>Maximum Axle Weight (kg)</th>
<th>Maximum Wheel Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1.35</td>
<td>12,000</td>
<td>6,000</td>
</tr>
<tr>
<td>≥ 1.35</td>
<td>12,500</td>
<td>6,250</td>
</tr>
</tbody>
</table>

Table A.1: Maximum Axle Weight and Minimum Spacing for Category 2 Vehicles
### Table A.2: Maximum Axle Weight and Minimum Spacing for Category 3 Vehicles

Note that the above weight limits apply to vehicles or a combination of vehicles carrying the load. Vehicles drawing the abnormal indivisible load but not carrying any part of the load are assessed separately. Thus for example, the total weight of the vehicle train i.e. a locomotive pulling a trailer carrying the abnormal load, can exceed the maximum limits for the above respective vehicle categories.
ANNEX B  BASIS OF SV AND SOV LOAD MODELS FOR ASSESSMENT

B1  Background

Until the introduction of Eurocodes bridges and other highway structures should have been designed for the Type HB loading given in BD 37 (DMRB 1.3), which is intended to cover the effects of STGO vehicles. In some cases a small number of specific Special Order (SO) vehicles are also considered during design. The set of BE-AIL vehicles produced by the then Bridges Engineering Division of Department of Transport have been used for this purpose in many cases.

The Type HB loading model has also been used in assessment to assess for the effects of STGO vehicles as there was no assessment standard available. Studies have shown that the Type HB loading model does not represent accurately the effects of real STGO vehicles. In particular, because of the high axle weights, the Type HB model is excessively conservative for very short span structures. However, this conservatism reduces for spans of 15 to 30m, and in fact it is seen that real STGO vehicles can produce more severe load effects than an Type HB model vehicle of the same gross weight. This is because the real STGO vehicles have more axles which are more closely spaced than those of the Type HB model vehicle.

In the case of Special Order vehicles, structures on the notified route are checked for their adequacy to support each notified vehicle. The checking could involve a simple comparative assessment of the actual SO vehicle against the Type HB capacity for the structures or in some cases a full structural assessment is carried out using the notified vehicle. Structures which are deficient may require strengthening to carry the SO vehicle if a suitable alternative route cannot be found. This approach can result in considerable delays and costs to the industry, as well as imposing an administrative burden on highway authorities.

Standard SV and SOV load models given in this standard were developed to cater for the effects of the majority of STGO and SO vehicles to expedite the process of clearing movement requests.

B2  Comparison of Type HB Loading against the Effects of Real STGO and SO Vehicles

Figures B.1 and B.2 compare the load effects produced by STGO Category 3 and Category 2 vehicles, respectively, against various units of Type HB loading. The effects from STGO vehicles are based on an extensive database of STGO vehicle notifications and the data from a weigh-in-motion station on the M40 motorway, and represent the maximum values obtained at each span. Effects from hypothetical vehicles that conform to the extreme allowable limits of the existing STGO regulations are also included for comparison.

In the above comparison, overloading and dynamic amplification factors are not included in calculating STGO load effects and no partial factors are applied to the effects from Type HB vehicles. The influence line for the mid-span moment of a simply supported beam is used, and it is assumed that there will be only one abnormal vehicle on the bridge at any one time. Associated Type HA loading or AW vehicle loading has not been applied.

From these figures it can be seen that the 45 units of Type HB loading (used for the design of structures carrying motorway and trunk roads), although encompassing the effects of all STGO vehicles, can be excessively conservative for structures less than about 10m span.

37.5 units of Type HB loading (with a gross weight of 150 tonnes), on the other hand, although it is conservative for spans of less than 10m, on longer spans it does not cater for the effects produced by STGO Category 3 vehicles with gross weights of up to 150 tonnes. Similarly, 25 units and 20 units of Type HB loading do not cater for the effects of Category 3 vehicles of up to 100 tonnes and Category 2 vehicles of up to 80 tonnes gross weight respectively.
Figure B.1: Comparison of STGO Category 3 Vehicle Effects Against Type HB Loading

Figure B.2: Comparison of STGO Category 2 Vehicle Effects Against Type HB Loading
The Type HB loading model is similarly compared against the effects of real SO vehicles in Figure B.3. The Axle loads and spacing for real vehicles were taken from the 36 drawbar multi-trailer SO vehicle movements that took place in the years 2004 and 2005. The plots show the equivalent Type HB units of the effects produced by real SO vehicles considering mid-span bending moment of a simply supported beam.

The plots show that a significant number of real SO vehicles produce more severe effects than 45 Units of Type HB loading beyond about 20 m span. Similar conclusions are obtained for other types of SO vehicles and different influence line types.

It is, therefore, clear that separate load models are required to adequately represent the effects of real STGO and SO vehicles. The SV and SOV models given in this standard have been developed to meet this need.

![Figure B.3: Comparison of SO Vehicle Effects Against Type HB Loading (y-axis Shows Units of HB)](image)

### B3 SV Load Model Configurations

In developing the SV load model configurations, the following data sources were used:

(i) Data from some 15000 STGO and SO vehicle transit notifications received by Kent County Council from 1997 to 1999.

(ii) Weigh-in-Motion (WIM) data from the M25 and M40 motorways over a three-month period during the year 2000.

The data was carefully screened and SO vehicles were removed from the data set. In addition, a number of hypothetical vehicles that conform to the extreme allowable limits of the existing STGO regulations were included. The data was analysed to produce histograms of speeds, gross weights, vehicle lengths, vehicle widths, number of axles, maximum axle weights, and minimum axle spacings.

For each vehicle in the data set, the load effects were calculated considering influence lines for the midspan moment and for the end shear of a simply supported beam and for the support moment of a continuous beam. Maximum load effects at each span were determined and compared against the load effects from 45 units of Type HB loading. The comparisons for midspan moment of a simply supported beam are shown in Figures B.1 and B.2. Partial Factors, Overload Factor, DAF and associated Type HA loading or AW vehicle loading are not included in these comparisons.
Trial SV load model axle configurations were chosen to match closely with those of the real STGO vehicles and their load effects were calculated. The configurations were refined until the load effects from the SV load models enveloped the maximum load effects from the STGO vehicles in the data set. The load effects from the proposed SV load model configurations are compared with the load effects from STGO vehicles and Type HB loading in Figure B.4 for Category 3 vehicles and in Figure B.5 for Category 2 vehicles. It can be seen that, compared to the Type HB model, the SV load models provide a better match to the load effects from the STGO vehicles in their respective categories.

Figure B.4: Comparison of STGO Category 3 Vehicle Effects Against SV Load Models

Figure B.5: Comparison of STGO Category 2 Vehicle Effects Against SV Load Models
B4 Configuration of SOV Load Models

Unlike the STGO vehicles there are no regulations in the UK which control the configuration (i.e. axle loads, spacing, etc.) of SO vehicles. As a result it is not feasible to develop standard loading models to cater for the effects of virtually any configuration of SO vehicle. However, if certain limits on key vehicle configuration parameters can be agreed it is possible to develop standard models to cater for SO vehicles within these limits.

The data held by the Highways Agency on some 450 SO vehicles over 150 tonnes moved over the period 2000 to 2005 was examined. However, detailed data on vehicle characteristics were available only for some 130 vehicles which were moved during the years 2004 and 2005 (see reference 6). Analysis of this data showed that standard models can be developed to cater for over 95% of SO vehicles of the following types that are commonly used:

* articulated tractor and semi-trailer vehicles;
* drawbar trailer vehicles;
* girder frame trailer vehicles.

The self-propelled modular trailers (SPMT) are seen to move over very short distances typically within a factory or construction yard to carry very large and prefabricated structures. They have quite unique configurations and it would be difficult to standardise these. Hence SPMT vehicles were excluded from the development of standard models. Structures would need to be designed and assessed individually for these vehicles.

Load effects were calculated for all the SO vehicles over 150 tonnes recorded during 2004 and 2005. The vehicle effects were converted to equivalent Type HB Units and plotted as illustrated in Figure B.3. It can be seen that the effects of real vehicles range from some 20 to 140 equivalent Units of Type HB. Based on the results of load effects critical vehicles from each type were identified.

Four standard loading models were developed to cater for vehicles with maximum trailer weights as below:

- **SOV-250** – Maximum total weight of SO trailer units up to 250 tonnes
- **SOV-350** – Maximum total weight of SO trailer units up to 350 tonnes
- **SOV-450** – Maximum total weight of SO trailer units up to 450 tonnes
- **SOV-600** – Maximum total weight of SO trailer units up to 600 tonnes

This gives flexibility for highway authorities to assess structures on a route to cater for SO vehicles most likely to use that route.

The configuration of the SOV models (i.e. axle and wheel load arrangements of tractors and trailers) were established considering the general characteristics of real SO vehicles and based on an examination of the critical vehicles producing the most severe load effects.

Figure B.6 shows normalised results (load effect of real vehicle divided by the load effect of the load model) for all critical vehicles with trailer weights of up to 350 tonnes considering a range of influence line types. For comparison, equivalent values for 45 Units of Type HB are also included. The maximum values (ignoring the diamonds representing the Type HB vehicle) are all less than 1.0 suggesting that the SOV-350 model safely envelopes the load effects from critical vehicles in the abnormal database.

Comparison of all the SOV load models were made against the real vehicles recorded in the database using beam influence lines of varying spans for five different load effects and four real bridges of different structural forms. The results confirmed that the SOV models closely represent the effects of real SO vehicles and optimally cater for the most severe effects of real SO vehicles within the specified configuration limits. In comparison the Type HB model is seen to be very conservative for spans less than about 15 m but becomes increasingly less onerous than the effects of real vehicles even for trailer weights up to 250 tonnes.
### B5 Overload Factor

STGO vehicles may be overloaded above the weights notified by the hauliers. At present there is no systematic data available from roadside surveys to determine the level of overloading. The WIM data was compared with the data from notifications for the same route and the same period to get some indication of the overloading. Although it is not possible to identify individual vehicles from the WIM data, generally a greater number of heavier vehicles were observed in the WIM data compared to the notifications. In particular, there was a large number of vehicles with axle weights heavier than 16.5 tonnes (the upper limit for Category 3 STGOs) and further examination revealed that these were not SO vehicles. Significant overloading can occur on individual axles because of an uneven distribution of the total load to the different axles.

Based on the above observations, the Overload Factor was assumed to be 1.2 for the worst effective axle and 1.1 for all other axles of SV load models. As the number of axles present over the loaded length increases, the overall Overload Factor should reduce.

Since there is no data available on the levels of overloading of SO vehicles, this is assumed to be of similar order as the STGO vehicles and hence the same Overload Factors are used for both SV and SOV load models.

### B6 Dynamic Amplification Factor

Dynamic effects from vehicles arise principally from two sources: (i) whole-body bounce, and (ii) individual axle impact. A study carried out by Flint & Neill Partnership (see reference 1) based on measurements undertaken by TRL (see reference 2) established characteristic Dynamic Amplification Factors (DAF) for normal HGVs of 1.25 for ‘good’ road surfaces and 1.38 for ‘poor’ road surfaces. For structures close to 40m in span, where typical vehicle frequencies may match bridge frequencies, higher values than the above are possible. Although the dependency on speed was less significant at higher speeds, slow speed transits (at less than 10 mph) were seen to cause little dynamic response. Another important observation was that the dynamic component of the loading (not the factor) was relatively independent of the weight of the vehicle; so
that the DAF actually decreases as the vehicle weight increases. This observation has been confirmed by a number of other studies carried out overseas.

There is no data available at present on the dynamic effects caused by abnormal vehicles. The STGO and SO vehicles could be expected to have lower DAF values than normal HGVs because of their heavier weights, lower speeds and generally better suspension systems.

It is also likely that axle impacts from different axles would be uncorrelated and hence the overall dynamic load should reduce as the number of axles on the loaded length increases, however, this effect could not be incorporated in the expression for DAF due to lack of data. Where the speed of the STGO or SO vehicle is restricted to less than 10 mph, the DAF factor is reduced to 1.0.

B7 Partial Load Factors for ULS

The partial load factor of 1.3 currently used on Type HB loading was assumed to cater for overloading and dynamic effects. Since these effects are explicitly considered in deriving the Type SV and Type SOV assessment live load, a lower partial load factor of 1.10 was adopted. The values of the partial factor, the Overload Factor and the Dynamic Amplification Factor were chosen together to ensure that the new SV model was no more onerous than the 45 units of Type HB loading which is the current design load level for motorway structures. The partial load factor on the Type HA loading associated with the Type SV or Type SOV loading is retained at 1.3 as at present.

B8 Lift-off Factors for Masonry Arches

Double and triple axle bogies do not compensate well over the crest of hump arch bridges. The current requirements in BD 21 recognise that, with AW vehicles, the worst case in this respect occurs with steel suspension systems. For air or fluid suspension systems the lift-off factor is 1.0. This does not infer that there is no load transfer with air or fluid suspensions but that it is a significantly lower proportion. A large proportion of STGO and SO vehicles however have robust all-terrain fluid suspensions with high-unsprung axle weights. The inertia in these systems is likely to be significant and therefore a lift-off factor will need to be applied to the SV and SOV load models on structures where the lift-off condition is likely to occur.

B9 Limitations

The Type SV and Type SOV assessment loading models have the following limitations:

(i) The likelihood of two or more STGO and/or SO vehicles occurring simultaneously within a lane or in adjacent lanes over a bridge is not accounted for. This is not admissible in current regulations.

(ii) The models have been developed based on ‘declared weights’ from hauliers. The Overload Factor and the partial factor are intended to cater for minor unavoidable variations from declared weights that can occur in practice. The models do not cater for overloading due to negligence, deliberate under-declaration or lack of knowledge about axle loads of abnormal loads. This should be managed by stringent enforcement of the abnormal load movement system.

(iii) The braking and acceleration forces specified are based on judgement and extrapolation of available test results; further research is needed to confirm these values.

(iv) The SV model does not cater for the possibility of locomotives heavier than that used for the SV-Train load model or for the possibility of more than one locomotive pushing or pulling the trailer.
ANNEX C  TYPE HB-TO-SV CONVERSION CHARTS

C1 General
Where existing Type HB ratings for highway bridges and structures are available and the Overseeing Organisation is satisfied with the manner in which these have been derived, the corresponding Reserve Factors for SV load models can be obtained approximately using the Type HB-to-SV Conversion Charts given in this Annex. Worked examples using these Conversion Charts are given in C5 and C6.

C2 Conversion Factor
The Reserve Factor $\Psi_{SV}$ for a SV load model should be calculated from the Type HB rating, $N_{HB}$ number of units, for a structure as below:

$$\Psi_{SV} = \lambda^*_{HB45-SV} \times \frac{N_{HB}}{45}$$  \hspace{1cm} (C.1)

In the above, $\lambda^*_{HB45-SV}$ is the Conversion Factor from 45 units of Type HB loading to an equivalent SV load model calculated as below:

$$\lambda^*_{HB45-SV} = \frac{S_{HB45}}{S_{SV}}$$  \hspace{1cm} (C.2)

where $S_{SV}$ and $S_{HB45}$ are, respectively, the factored load effect due to a SV load model and that due to 45 units of Type HB loading, both calculated using an influence line appropriate for the structure being considered. The Conversion Factor should be obtained from the Conversion Charts given in Figures C.7 to C.12.

C3 Conversion Charts
In producing the Conversion Charts, the load effect $S_{SV}$ has been calculated including the Overload Factor ($OF$), the Dynamic Amplification Factor ($DAF$) and a partial factor for load of $\gamma_{FL}=1.1$, while the load effect $S_{HB45}$ has been calculated with a partial factor for load of $\gamma_{FL}=1.3$.

The effect of associated Type HA loading (in the same lane as the abnormal vehicle and in adjacent lanes) has been assumed to be the same for the SV and Type HB load models, and hence is not included in calculating the load effects. Since the Type HB load models are wider than the SV load models, they displace more of the Type HA loading in adjacent lanes than the SV load models do. The Conversion Charts should not be used for two or more notional lanes of widths 2.75m to 3.0m as the Type HA loading associated with the Type HB load model would be significantly lower than that associated with the SV load models for these cases.

Where the previous Type HB ratings have been derived without the associated Type HA loading in any of the lanes, the use of the Conversion Charts and equation C.1 gives the Reserve Factors $\Psi_{SV}$ for SV load models without the associated Type HA loading.

The Conversion Charts have been developed for the following influence lines:

- Single simply supported span: Mid-span moment.
- Single simply supported span: Support shear/support reaction.
- Continuous spans: Mid-span moment.
- Continuous spans: Internal support moment.
- Continuous spans: Internal support shear.
- Continuous spans: Internal support reaction.

The influence lines for the above load effects are illustrated in Figures C.1 to C.6 for a loaded length (L) of 15m. For continuous spans, various proportions of individual span lengths were considered and the lowest Conversion Factor was used in producing the Conversion Charts.

For each influence line, Conversion Factors $\lambda^*_{HB45-SV}$ have been produced for each of the five SV load models (SV80, SV100, SV150, SV-Train and SV-TT) and are presented in Figures C.7 to C.12.

The assessing engineer should use the Conversion Chart which is based on the influence line that is the most appropriate for the structure being considered and the governing load effect. If none of the influence lines shown in Figures C.1 to C.6 is appropriate then the Conversion Charts should not be used. In this case the Conversion Factor should be derived from equation C.2.
based on the load effects calculated for the 45 units of Type HB vehicle and the various SV load models using the influence line/surface specific to the structure being considered. Alternatively the structure could be assessed directly using the SV load models.

C4 Limitations

The following limitations apply to the Conversion Charts:

1. Only the “normal flow” case with full impact has been considered for the SV load model for comparison with the Type HB load effect.

2. The charts do not take into account the associated Type HA loading explicitly but assume that the Type HA load effects are the same for the Type HB and SV assessments.

3. The influence lines for which the conversion charts are produced may not be appropriate for transversely spanning decks/members, trough decks, masonry arches, buried structures, and bridges curved in plan with radius of curvature of less than 600m.

Taking account of the above limitations, the assessing engineer should ensure that the use of the Conversion Charts for the specific structure being considered provides a conservative estimate of the Reserve Factor for SV load models.

C5 Example 1

A simply supported RC slab bridge with a span of 10m has an Type HB rating of 34 Units with the associated Type HA loading included and 48 Units without the associated Type HA loading. The Conversion Factors for 45 Units of Type HB loading for mid-span moment and support shear can be obtained from Figures C.7 and C.8, and these are listed in Table C.1. The minimum value of the Conversion Factors for moment and shear are then used to calculate the Reserve Factors for SV load models. In using Equation C.1, the Type HB rating of 34 Units is used to calculate the Reserve Factors with the associated Type HA loading (Ψsv) and 48 Units for Reserve Factors without the associated Type HA loading (Ψsv*). The Vehicle Rating, which is the least Reserve Factor greater than unity, is SV80 with associated Type HA loading and SV-Train or SV150 without the associated Type HA loading.

<table>
<thead>
<tr>
<th>Load Model</th>
<th>Conversion Factors λ_{HB45→SV}</th>
<th>Reserve Factors</th>
<th>Reserve Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Moment</td>
<td>Shear</td>
<td>Minimum</td>
</tr>
<tr>
<td>SV80</td>
<td>1.34</td>
<td>1.58</td>
<td>1.34</td>
</tr>
<tr>
<td>SV100</td>
<td>1.12</td>
<td>1.28</td>
<td>1.12</td>
</tr>
<tr>
<td>SV150</td>
<td>1.12</td>
<td>1.28</td>
<td>1.12</td>
</tr>
<tr>
<td>SV-Train</td>
<td>1.12</td>
<td>1.28</td>
<td>1.12</td>
</tr>
<tr>
<td>SV-TT</td>
<td>1.70</td>
<td>1.95</td>
<td>1.70</td>
</tr>
</tbody>
</table>

Table C.1: Conversion Factors λ_{HB45→SV} and Reserve Factors for Single Span of 10m
C6 Example 2

A three span continuous RC slab bridge with spans 10m:15m:10m has a Type HB rating of 37.5 units with the associated Type HA loading included. The Conversion Factors for 45 units of Type HB loading for the various load effects can be obtained from Figures C.9 to C.12, and these are listed in Table C.2. The minimum value of the Conversion Factors for the different load effects are then used to calculate the Reserve Factors for SV load models based on equation C.1. The Vehicle Rating of the structure is, therefore, SV80.

<table>
<thead>
<tr>
<th>Load Model</th>
<th>Conversion Factors $\lambda_{\text{HB}45 SV}$</th>
<th>Reserve Factor $\psi_{SV}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mid-span Moment</td>
<td>Support Moment</td>
</tr>
<tr>
<td></td>
<td>L=15m</td>
<td>L=25m</td>
</tr>
<tr>
<td>SV80</td>
<td>1.38</td>
<td>1.60</td>
</tr>
<tr>
<td>SV100</td>
<td>1.12</td>
<td>1.30</td>
</tr>
<tr>
<td>SV150</td>
<td>1.02</td>
<td>1.04</td>
</tr>
<tr>
<td>SV-Train</td>
<td>1.05</td>
<td>0.96</td>
</tr>
<tr>
<td>SV-TT</td>
<td>1.75*</td>
<td>1.70</td>
</tr>
</tbody>
</table>

Note: * Based on L=10m

Table C.2: Conversion Factors $\lambda_{\text{HB}45 SV}$ and Reserve Factors
Figure C.1: Influence Line for Single Span: Mid-span Moment (L=15m)

Figure C.2: Influence Line for Single Span: Support Shear/Support Reaction (L=15m)

Figure C.3: Influence Line for Continuous Spans: Mid-span Moment (L=15m)
Figure C.4: Influence Line for Continuous Spans: Internal Support Moment:
(L = Sum of adjacent span lengths = 15m)

Figure C.5: Influence Line for Continuous Spans: Internal Support Shear (L=15m)

Figure C.6: Influence Line for Continuous Spans: Internal Support Reaction:
(L = Sum of adjacent span lengths = 15m)
Figure C.8: $\lambda_{HB45-SV}$ for Single Span: Support Shear/Reaction
Figure C.9: $\lambda_{HB_{45-SV}}$ for Continuous Spans: Mid-span Moment
Figure C.10: $\lambda_{HB45-SV}$ for Continuous Spans: Internal Support Moment
Figure C.11: $\lambda_{\text{HB45-SV}}$ for Continuous Spans: Internal Support Shear
Figure C.12: $\lambda_{HV-SV}$ for Continuous Spans: Internal Support Reaction
ANNEX D  MANAGEMENT OF STGO VEHICLE MOVEMENTS

D1  General

When the highway authority or its appointed agent receives a notification from a haulier for the movement of a STGO vehicle, the suitability of the vehicle to pass over a specific structure may be assessed using the procedures given in this Annex. A separate check should be made for adequate height and width clearances for the safe travel of the STGO vehicle.

The assessment should be performed in stages, starting with the simple screening method given in D2, which should be sufficient for the majority of the vehicles. When the vehicle fails the screening level check, a more detailed assessment should be performed using the method given in D3.

Reductions to Dynamic Amplification Factor, the associated Type HA loading (or AW vehicle loading), and the Overload Factor may be made, e.g. where the transit is well regulated and there is a greater confidence in the weight of the STGO vehicle as given in D4 to D6.

Highway authorities and their appointed agents should be aware that checking for ULS only may result in serviceability problems and possible permanent damage. This is most likely where methods of analysis are used at ULS, which rely on large amounts of redistribution e.g. concrete structures.

Worked examples using the procedures in this Annex are given in D9 to D11.

D2  Screening Assessment

Comparing the vehicle type, gross weight, axle weight and axle spacing characteristics of the notified STGO vehicle against the limits set out in Table D.1 identify the applicable SV load models for which these limits are satisfied. The STGO vehicle or vehicle train with a total weight of WSTGO tonnes may be considered suitable to pass a specific structure if:

\[ W_{STGO} \leq W_{SV} \times \Psi_{SV} \]  \hspace{1cm} (D.1)

where \( W_{SV} \) is the gross weight of the applicable SV load model from Table D.1 and \( \Psi_{SV} \) is the corresponding Reserve Factor determined as in 3.44. The Screening Assessment should only be used if the relevant conditions in the following are satisfied:

(i) for a notified vehicle with maximum axle weight of 12.5 tonnes and minimum axle spacing of 1.2 m, the structure Reserve Factor \( \Psi_{SV} \) for SV80 is \( \geq 1.0 \); or

(ii) for a notified vehicle with maximum axle weight of 12 tonnes and minimum axle spacing of 1.1 m, the structure Reserve Factor \( \Psi_{SV} \) for SV80 is \( \geq 1.0 \); or

(iii) for a notified vehicle with maximum axle weight of 16.5 tonnes and minimum axle spacing of 1.2 m, the structure Reserve Factor \( \Psi_{SV} \) for SV100 is \( \geq 1.0 \); or

(iv) for a notified vehicle with maximum axle weight of 15 tonnes and minimum axle spacing of 1.1 m, the structure Reserve Factor \( \Psi_{SV} \) for SV100 is \( \geq 1.0 \).

The locomotive axles, which have axle weights up to 18 tonnes but a spacing \( > 1.6 \)m, can be ignored in the above checks.
### STGO Vehicle Characteristics

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Max. Axle Weight (tonnes) &amp; Min. Axle Spacing (m)</th>
<th>Load Model</th>
<th>Gross Weight $W_{sv}$ (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Vehicle</td>
<td>16.5t @ 1.2m, OR</td>
<td>SV80</td>
<td>80</td>
</tr>
<tr>
<td>≤ 150t gross weight</td>
<td>15.0t @ 1.1m</td>
<td>SV100</td>
<td>100</td>
</tr>
<tr>
<td>Single Vehicle</td>
<td>16.5t @ 1.35m, OR</td>
<td>SV150</td>
<td>150</td>
</tr>
<tr>
<td>≤ 150t gross weight</td>
<td>15.0t @ 1.2m</td>
<td>SV-Train</td>
<td>Trailer 150</td>
</tr>
<tr>
<td>Trailer</td>
<td>16.5t @ 1.35m, OR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Locomotive</td>
<td>15.0t @ 1.2m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 46t gross wt.</td>
<td>Two axles 18t @ 1.6m; additional axles min. 4m apart</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:**
1. The axle weights and spacings do not necessarily correspond to the STGO Regulations but are related to the parameters for which STGO vehicles may be directly compared to SV load models in the Screening Assessment.
2. In cases where more than one SV load model meets the STGO vehicle characteristics, the most favourable of these can be used in applying Equation D.1.
3. Vehicle train comprises a single locomotive pulling a trailer.

### Table D.1: STGO and SV Load Models Characteristics for Screening Assessment

#### D3 Detailed Assessment

The detailed assessment should be based on a comparison of the load effects caused by the STGO vehicle with those of the SV load model using one or more influence lines considered most appropriate for the structure. Overload Factor (OF), Dynamic Amplification Factor ($DAF$) and partial factors $\gamma_{fl}$ and $\gamma_D$ should not be applied in calculating the load effects due to both the SV load model and STGO vehicle as these factors would have already been incorporated in the calculation of the reserve factor for SV.

The calculation of load effects due to the STGO vehicle and the SV load model should be refined in two steps as below:

1. Calculate the unfactored load effects due to the STGO vehicle, $S_{STGO}$, and the SV load model, $S_{sv}$, ignoring the associated Type HA loading (or AW vehicle loading). The STGO vehicle should be considered suitable to pass the structure if:

   \[ S_{STGO} \leq S_{sv} \times \Psi_{sv} \]  

   (D.2)

   The above assumes that the load effects due to the associated Type HA loading (or AW vehicle loading) is the same for both SV and STGO vehicles.

2. Where the inequality (D.2) is not satisfied, calculate the unfactored load effects due to both STGO and SV load models including the unfactored associated Type HA loading (or AW vehicle loading) applied using 3.20 - 3.30 with the DAF set to 1.0. The STGO vehicle should be considered suitable to pass the structure if the following condition is satisfied for both the 'normal speed' and 'low speed' cases:

   \[ (S_{STGO} + S_{HA(STGO)}) \leq (S_{sv} \times \Psi_{sv} S_{HA(SV)}) \]  

   (D.3)

   where $S_{HA(STGO)}$ is the unfactored load effect due to the Type HA loading (or AW vehicle loading) associated with the STGO vehicle, while $S_{HA(SV)}$ is the unfactored load effect due to the Type HA loading (or AW vehicle loading) associated with the SV load model. This refinement is likely to be beneficial for loaded lengths greater than about 15m. In this case, since the real STGO vehicles would in general be longer than the SV load models, $S_{HA(STGO)}$ would be lower than $S_{HA(SV)}$.

#### D4 Reduction in Dynamic Amplification Factor

For a STGO vehicle that marginally exceeds the assessed capacity of a structure, it may be possible to permit its passage provided its speed over the structure
can be restricted to less than 10 mph. The STGO vehicle should be considered suitable to pass the structure if:

\[
(S_{STGO} \times DAF_{STGO}) \leq (S_{SV} \times DAF_{SV} \times \Psi_{SV})
\]  

(D.4a)

where \(DAF_{STGO} = 1.0\) is the Dynamic Amplification Factor applied to the STGO vehicle, while \(DAF_{SV}\) is the Dynamic Amplification Factor applied to the SV load model taken as in 3.17.

Alternatively, when the effect due to the associated Type HA loading (or AW vehicle loading) is taken into account the STGO vehicle should be considered suitable to pass the structure if the following condition is satisfied for both the ‘normal speed’ and the ‘low speed’ case:

\[
(S_{STGO} \times DAF_{STGO} + S_{HA(STGO)} \leq (S_{SV} \times DAF_{SV} \times \Psi_{SV} S_{HA(SV)})
\]  

(D.4b)

In this case the Type HA loading should be applied using 3.20 – 3.30 assuming that the SV load model and STGO vehicle lie fully within a notional lane (see Figure 3.9). The value of \(DAF_{SV}\) should be taken as in 3.17 for the ‘normal speed’ case and as 1.0 for the ‘low speed’ case. For masonry arches the lift-off can be ignored for the ‘low speed’ case.

D5 Reduction in Associated Type HA Loading or AW Vehicle Loading

For a STGO vehicle that marginally exceeds the assessed capacity of a structure, it may be possible to permit its passage provided the vehicle is escorted and the structure is kept clear of associated normal traffic. Two cases can be considered:

(i) When the associated traffic in the same lane as the STGO vehicle is kept clear over the span, the STGO vehicle should be considered suitable to pass the structure if the following condition is satisfied for both the ‘normal speed’ and the ‘low speed’ cases:

\[
S_{STGO} \leq (S_{SV} \times \Psi_{SV} + S_{HA(SV)})
\]  

(D.5)

Where \(S_{HA(SV)}\) is the load effect due to the Type HA loading (or AW vehicle loading) in the same lane as the SV load model.

The load effects due to the SV load model and the associated Type HA loading (or AW vehicle loading) should be calculated using 3.20 – 3.30 with the \(DAF\) set to 1.0. The reduction in the \(DAF\) can also be allowed for as in D4 if the speed of the STGO vehicle over the structure is restricted.

(ii) When the associated traffic in all lanes of the carriageway is kept clear of the structure, the STGO vehicle should be considered suitable to pass the structure if:

\[
S_{STGO} \leq (S_{SV} \times \Psi^{*}_{SV})
\]  

(D.6)

where \(\Psi^{*}_{SV}\) is the Reserve Factor without the associated Type HA loading (or AW vehicle loading) as determined in 3.45.

The reduction in \(DAF\) can also be allowed for as in D4 if the speed of the STGO vehicle over the structure is restricted.

D6 Reduction in Overload Factor

Where there is a greater confidence in the gross weight and axle weights of the STGO vehicle, the value of the Overload Factor can be reduced as shown in Table D.2. The STGO vehicle should be considered suitable to pass the structure if:

\[
(S_{STGO} \times OF_{STGO}) \leq (S_{SV} \times OF_{SV} \times \Psi_{SV})
\]  

(D.7a)

OR

\[
(S_{STGO} \times OF_{STGO} + S_{HA(STGO)} \leq (S_{SV} \times OF_{SV} \times \Psi_{SV} S_{HA(SV)})
\]  

(D.7b)

where \(OF_{even} \) is the Overload Factor from Table D.2

\[
(S_{STGO} \times OF_{STGO} \times DAF_{STGO} \times S_{HA(STGO)}) \leq (S_{SV} \times OF_{SV} \times DAF_{SV} \times \Psi_{SV} S_{HA(SV)})
\]

Overload factor from 3.16 applies to the SV load model. Using equation D.7b, the reduction in Overload Factor can be combined with reductions in the Dynamic Amplification Factor and the associated Type HA loading (or AW vehicle loading) as given in D4 and D5.

<table>
<thead>
<tr>
<th>Level of confidence in the weight of the STGO vehicle</th>
<th>Overload Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent certification of the ‘load’ carried or the total weight of the vehicle(s)</td>
<td>0.95 \times OF</td>
</tr>
<tr>
<td>Independent certification of all axle weights and spacing</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Table D.2: Overload Factor OFSTGO Applied to the STGO Vehicle

(OF is the Overload Factor from 3.16)
D7 Route Assessment

Highway authorities may pre-assess all structures on identified heavy load routes (including slip roads and interchanges on the way) using the procedures given in D1 to D3 and assign a rating for the route. The Route Rating should be taken as the lowest of the Vehicle Ratings for all the structures on that route. This can facilitate a speedier assessment of STGO notifications.

D8 Vehicle Assessment

Some STGO vehicles (for example mobile cranes) have fixed axle weight and spacing configurations and they perform frequent transits around the country. These vehicles may be pre-assessed by the haulier (or the highway authority) using the simple screening assessment method given in D2 to determine their equivalent SV ratings or Reserve Factors against SV load models. This information could then be supplied on the notification forms to facilitate speedier assessments.

D9 Example 1: Screening Assessment

A notification has been received from a haulier for moving a mobile crane of 98 tonnes gross weight over a stretch of the road comprising four bridges. The axle loads and configuration of the vehicle are shown in Figure D.1. The Reserve Factors for the four bridges are given in Table D.3. All the bridges have simply-supported reinforced concrete slab decks.

![Figure D.1: Notified Vehicle 1](image1)

<table>
<thead>
<tr>
<th>Bridge Ref.</th>
<th>SV Reserve Factors, ( \Psi_{sv} ) for Flexure</th>
<th>( W_{sv} \times \Psi_{sv} )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SV80</td>
<td>SV100</td>
</tr>
<tr>
<td>A</td>
<td>1.58</td>
<td>1.28</td>
</tr>
<tr>
<td>B</td>
<td>1.54</td>
<td>1.21</td>
</tr>
<tr>
<td>C</td>
<td>1.25</td>
<td>1.02</td>
</tr>
<tr>
<td>D</td>
<td>1.28</td>
<td>1.01</td>
</tr>
</tbody>
</table>

Table D.3: SV Reserve Factors for Bridges

The STGO vehicle satisfies axle weight, spacing and Reserve Factor limits corresponding to SV80 and SV100 load models and hence the screening assessment is applicable for this case.

The gross weight, \( W_{sv} \), for the SV80 and SV100 load models can be obtained from Table D.1 and these have been multiplied by the corresponding Reserve Factors from Table D.3. The results are summarised in Table D.4.

![Table D.4: SV Load Model Load Ratings (Tonnes) for Bridges](image2)

Since the total weight of the STGO vehicle, \( W_{STGO} = 98t \), is less than the product of \( W_{sv} \times \Psi_{sv} \) for all the four bridges, the STGO can be considered to be safe to travel on the specified route. A check was also made for shear load effect and the STGO vehicle was seen to be acceptable for this case.

D10 Example 2: Detailed Assessment

A second notification for the movement of an abnormal indivisible load has been received for the same stretch of the road as in Example 1. The total weight of the vehicle is 146 tonnes and the axle weight and configuration are as shown in Figure D.2.

![Figure D.2: Notified Vehicle 2](image3)
Referring to Table D.1, the vehicle does not satisfy the axle weight and spacing limits for single STGO vehicles and hence the Screening Assessment cannot be applied. Mid-span bending moments due to the STGO vehicle and the various SV vehicles were calculated for the four bridges and multiplied by the corresponding Reserve Factors from Table D.3. The results are summarised in Table D.5. The partial factor, the Overload Factor and the Dynamic Amplification Factor were not included in calculating the load effects for STGO and SV load models.

<table>
<thead>
<tr>
<th>Bridge Ref.</th>
<th>Span (m)</th>
<th>$M_{STGO}$</th>
<th>$M_{SV} \times \Psi_{SV}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>SV80</td>
</tr>
<tr>
<td>A</td>
<td>20</td>
<td>4391</td>
<td>5053</td>
</tr>
<tr>
<td>B</td>
<td>15</td>
<td>2847</td>
<td>3433</td>
</tr>
<tr>
<td>C</td>
<td>7.5</td>
<td>861</td>
<td>951</td>
</tr>
<tr>
<td>D</td>
<td>5.0</td>
<td>453</td>
<td>442</td>
</tr>
</tbody>
</table>

Table D.5: Mid-Span Bending Moments (kN-m) Due to STGO and SV Load Models

From Table D.5, it can be seen that the mid-span moment due to the STGO vehicle is less than the mid-span moment due to each of the SV load models multiplied by the corresponding Reserve Factors, i.e. equation (D.2) is satisfied for bridges A, B and C. However, this requirement is not satisfied for bridge D for which further assessment is required as considered in Example 3. The refinement given in Clause D3 (ii) was not applied as the loaded length for bridge D is less than 15m. A check was also made for the support shear and similar results were obtained.

**D11 Example 3: Regulated Movement of the STGO**

The detailed results available from the assessment of bridge D for the SV100 load model are given in Table D.6. The load effects do not include partial factors, the Overload Factor and the Dynamic Amplification Factor.

The load effects due to the STGO and SV load models were calculated for the following three alternative measures for regulating the movement of the STGO vehicle:

1. The STGO vehicle passes over the bridge at a speed of less than 10mph (see D4). The comparable load effects (see equation D.4a) for the SV100 load model are given in column 3 of Table D.7.

2. The STGO vehicle is escorted with the associated normal traffic kept clear of the bridge in all lanes (see D5). The comparable load effects (see equation D.6) for the SV100 load model are given in column 4 of Table D.7.

3. The haulier produces an independent certification of all axle loads and spacing of the STGO vehicle. The comparable load effects (see equation D.7a) for the SV100 load model are given in column 5 of Table D.7.

<table>
<thead>
<tr>
<th>Load Effect</th>
<th>$S_{H(ASV)}$</th>
<th>$S_{SV100}$</th>
<th>$\Psi_{SV100}$</th>
<th>$\Psi^*_{SV100}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moment (kN-m)</td>
<td>150</td>
<td>437</td>
<td>1.01</td>
<td>1.35</td>
</tr>
<tr>
<td>Shear (kN)</td>
<td>125</td>
<td>429</td>
<td>1.06</td>
<td>1.35</td>
</tr>
</tbody>
</table>

Table D.6: Detailed Assessment Results for Bridge D
<table>
<thead>
<tr>
<th>Load Effect</th>
<th>$S_{STGO}$</th>
<th>$S_{SV} \cdot \Psi_{SV} \cdot DAF_{SV}$</th>
<th>$S_{SV} \cdot \Psi_{SV}$</th>
<th>$S_{SV} \cdot \Psi_{SV} \cdot OF_{SV}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moment (kN-m)</td>
<td>453</td>
<td>495</td>
<td>591</td>
<td>501</td>
</tr>
<tr>
<td>Shear (kN)</td>
<td>433</td>
<td>508</td>
<td>580</td>
<td>488</td>
</tr>
</tbody>
</table>

Table D.7: Comparison of STGO and SV Load Effects for Bridge D with Alternative Management Measures

Based on the above results, it can be seen that the passage of the STGO vehicle over bridge D can be permitted with any one of the above three management measures.