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Document history

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Executive Summary

Highways England is concerned that current requirements and advice relating to junctions and connector roads are causing confusion. Atkins have been tasked to specifically consider corner radii, horizontal alignment and loops.

Five Requirements and Advice Documents (RADs) pertaining to the above parameters have been identified. These are TD 9, TD 22, TD 40, TD 41 and TD 42. Across these documents, a total of 59 clauses, figures and/or tables have been found to contain requirements/advice pertaining to the same.

Of the 59 clauses, 16 have been highlighted as providing conflicting information with other clauses. Notwithstanding this, 8 of these conflicts are between TD 40, TD 41 and TD 42 which will be resolved if the recommendations made as part of a recent TD 41 and 42 scoping study are enacted. This leaves 8 conflicting clauses which arise from 3 unique conflicts across the documents.

The first conflict (Conflict 1) relates to curve widening requirements between TD 40 and TD 42. Both documents provide differing requirements for what the widening should be for lanes on curves between 90m and 100m. In TD 40 this is 0.15m per lane and in TD 42 this is 0.3m per lane.

The second conflict (Conflict 2) relates to the differing minimum loop radii onto all-purpose roads between TD 40 and TD 22. In TD 22 the minimum required loop radius is 30m. TD 40 states that the desirable minimum radius of compact connector roads (loops) shall be 40m with a relaxation down to 32m being permissible. Interestingly, the compact loop minimum radius is greater than the minimum radius for full grade separated junctions.

The third conflict (Conflict 3) relates to nose tapers/hatching ratios. TD 22 and TD 42 (in addition to TSM Chapter 5) each prescribe different dimensions for nosings and physical island/ghost island tapers. Although the application and naming convention is different, each document details the ratio of the length to width of hatching designed to direct traffic past similar hazards for given design speeds. As such the reason for why these are different across the documents is not clear.

Following a meeting with the Highways England Project Sponsor, it was agreed that Conflict 1 could be relatively easily resolved by simple changes to the wording of the relevant clauses in TD 9; however, due to the more complex nature of Conflicts 2 and 3, it was agreed that more in-depth analysis would be required. This included the production of scale drawings in AutoCAD to assist in understanding the practical differences between the conflicting requirements. The further analysis for Conflict 2 also involved a review of the Bullen Consultants report that outlines the decision process behind the requirements included in TD 40.

Following completion of the additional analysis, it has been possible to provide a recommendation with a high level of confidence that will remove the inconsistency relating to two of three conflicts (Conflict 1 – Curve Widening and Conflict 2 – Loop Radii). It has however not been possible within the scope of this task to provide a recommendation to resolve Conflict 3 - Nose Ratio/Hatching Tapers. The level of inconsistency and lack of any apparent rationale for this means that further research in the form of off-road testing would be required to resolve this conflict. Notwithstanding this, there is no evidence to suggest that the inconsistency is causing particular safety issues on the network. While leaner and more aligned taper requirements could be developed, the cost of undertaking further research might not represent value for money. Highways England will therefore need to consider whether the inconsistencies in taper lengths across the documents represents a significant issue that justifies further investigation.

A summary of the recommendations made as part of this study are given in the table overleaf, which is an extract from Table 3-3 contained in the Summary and Recommendations section of this report (Section 3.5).
## Extract of Table 3-3

<table>
<thead>
<tr>
<th>Conflict</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Curve Widening</td>
<td>Change TD 9 Clause so that widening of 0.3m per lane shall only be provided for radii greater than 100m up to 150m. For Radii between 90m to 100m, TD 42 shall be used. The recommendation above resolves the conflict; however it is recommended that consideration is also given to changing TD 9 so that it prescribes a minimum curve widening width of 150mm per lane for standard width carriageways rather than 300mm. As part of this, the requirements for the widening of substandard width carriageways would need to be altered to suit.</td>
</tr>
<tr>
<td>2 – Loop Radii</td>
<td>Reduce the minimum loop radius for compact connector roads in TD 40 from 40m to 30m with no permitted relaxations. It is also recommended that the TD 22 approach for dealing with curve widening is adopted in TD 40 i.e. simply referring readers to TD 42. This would be a marked improvement as the current curve widening requirements in TD 40 have been noted to be somewhat ambiguous.</td>
</tr>
<tr>
<td>3 – Nose Ratio/Hatching tapers</td>
<td>Consider whether the inconsistencies in taper lengths across documents represents a significant issue that justifies further investigation. If the decision is taken that further research is required, off-road tests would represent a safe and suitable method of investigation.</td>
</tr>
</tbody>
</table>
1. Introduction

1.1. Background
Highways England is concerned that current requirements and advice relating to junctions and connector roads are causing confusion for designers and specialists. Atkins have been tasked to specifically consider the following parameters:

- Corner Radii;
- Horizontal Alignment; and
- Loops.

The following text is an extract from a query relating to the potential disparity between requirements for these parameters across Requirements and Advice (RAD) documents within the Design Manual for Roads and Bridges (DMRB):

“A scheme design has raised an issue regarding corner radius values. TD 42/95 clause 7.54 specifies minimum radii of 40m for routes with 120kph design speed and 20m for routes with 85kph design speed while TD 40/94 clause 6.20 specifies curve widening for 40m and 32m radii while clause 6.29 specifies a 20m radius for the channel line without mention of 32m or 40m radii”.

Highways England recognises that inconsistencies or lack of clarity can result in poor design decisions being made and can result in inconsistent provision across the trunk road network. Reducing the likelihood for misinterpretation will limit the risk of unsuitable provision occurring in the future.

1.2. Scope and Purpose
In response to the concerns highlighted above, Highways England has commissioned Atkins to undertake a study to determine where inconsistencies or lack of clarity exist and to develop recommendations to align requirements across DMRB RADs.

The first part of the process (identified as Work Package 2 in the Task Specification) is to identify those clauses within the applicable RADs that relate to the parameters listed in Section 1.1 and highlight:

- Any inconsistencies across the requirements and advice given;
- Any areas of ambiguity; and
- Any clauses, requirements and/or advice that may no longer be appropriate (as a result of recent research, legislation or best practice advice).

Subject to the findings of this exercise, the next stage of the study (identified as Work Package 3 in the Task Specification) is to provide recommendations as to how to resolve any issues identified.

The findings of Work Package 2 and 3 are detailed in Section 2 and 3 respectively.

1.3. Notes and Clarifications
The study has been split into three key Work Packages (WPs). WP1 involved the production of a project scoping report which was submitted in December 2015 (refer to Atkins document reference: PID Tasks 642 Version 2). The findings of WP2 were detailed in a Technical Note submitted in May 2016 (refer to Atkins document reference: 5146134.70.001). The content of this Technical Note has been incorporated in this report to provide a single source of reference for the technical work associated with this commission (Work Packages 2 and 3).

This study involves a review of TD 40, TD 41, TD 42 and TD 22. These documents have recently been the subject of two separate scoping studies. The key outputs of these studies is that TD 41 and TD 42 are to be combined into a single RAD, and TD 40 and TD 22 are to be combined into a single RAD. The recommendations made as part of this work will therefore need to be taken account of in the drafting stage for the replacement, combined RADs.
2. **Analysis of Relevant Clauses (WP2)**

2.1. **Line by Line Review Table**

They key output of this Work Package is the ‘line by line’ review table included in Appendix A. The table serves as a comprehensive assessment of each applicable clause. Table 2-1 provides an overview of the format of the table and a brief description of each column.

The key findings of the line by line review are summarised in Section 2.2.

**Table 2-1  Format of the Line by Line Review Table**

<table>
<thead>
<tr>
<th>Column Heading</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Doc</td>
<td>Reference number of the document the clause appears in.</td>
</tr>
<tr>
<td>Clause</td>
<td>Reference number as it appears in the parent RAD.</td>
</tr>
<tr>
<td>Subject</td>
<td>What subject the clause refers to e.g. ‘merges’.</td>
</tr>
<tr>
<td>Parameter</td>
<td>What parameter the clause relates to e.g. ‘dimensions’.</td>
</tr>
<tr>
<td>Clause Text</td>
<td>The current clause text.</td>
</tr>
<tr>
<td>Extracted Requirement/Advice</td>
<td>Concise summary of the relevant requirements or advice extracted from the clause.</td>
</tr>
<tr>
<td>Duplication/Conflict (across RADs)</td>
<td>An assessment of whether the principle of the requirements/advice is duplicated in other clauses contained in other RADs.</td>
</tr>
<tr>
<td>Duplication</td>
<td>An indication of whether there is conflict between this clause and clause(s) in other RADs where duplication (see above) has been identified (as applicable).</td>
</tr>
<tr>
<td>Conflict</td>
<td>Clause reference of the conflicting and/or duplicating clause(s) as it appears in the parent RAD (as applicable).</td>
</tr>
<tr>
<td>Doc</td>
<td>Reference number of the document the conflicting and/or duplicating clause(s) appears in (as applicable).</td>
</tr>
<tr>
<td>MDD Comments</td>
<td>Comments on the compliance of the current text with the Manual for Development of Documents.</td>
</tr>
<tr>
<td>General Comments</td>
<td>General comments concerning the appropriateness of the current text including the nature of any duplication/conflict.</td>
</tr>
<tr>
<td>Notes</td>
<td>Any notes concerning the comments made in the previous columns.</td>
</tr>
</tbody>
</table>

2.2. **Summary of Findings**

2.2.1. **Overview**

A total of five RADs have been identified containing requirements and advice pertaining to corner radii, horizontal alignment and loops. These are:

- TD 9
- TD 22
- TD 40
- TD 41
- TD 42

Across the five documents, a total of 59 clauses, figures and/or tables (herein referred to collectively as ‘clauses’ for simplicity) have been identified that provide requirements and advice pertaining to corner radii, horizontal alignment and loops. Figure 2-1 illustrates the split of these clauses across the five documents. The number of relevant clauses in each document ranges from ten (TD 41) to fifteen (TD 22).
The study team have also considered IAN 149/11 and 161/15, which describe requirements for a significant number of Highways England’s schemes. These documents are subject to separate on-going tasks to appraise and update them. They both present potential relaxations of certain requirements, including those in TD 22. In that respect they differ from TD 22, but no conflict or inconsistency is implied because IANs 149 and 161 both have defined scopes for application. For that reason, this task has focussed on the aforementioned DMRB RADs, which have a wider application and more potential for overlap, inconsistency or conflict.

2.2.2. Duplication

Each of the 59 clauses has been assessed for duplication against the requirements/advice given in in the other 58 clauses. Each clause falls into one of the three following categories under the ‘duplication’ heading:

- None;
- In Principle; or
- Potential.

‘None’ indicates that the nature of the requirement/advice is not duplicated in any way across the other documents.

‘In Principle’ relates to clauses where the nature of the requirement/advice is the same but the wording or specific parameters may be different.

‘Potential’ relates to clauses where the issue of duplication and therefore conflict is not clear. While the requirements across the clauses in question relate to similar features, the application is different which may explain the difference(s).

Of the 59 clauses, 19 fall into either the ‘in principle’ or ‘potential’ categories. The split of clauses across each of the categories is illustrated in Figure 2-2.
2.2.3. Conflict
The 19 clauses that have been highlighted as duplication or potential duplication have been assessed for conflict and placed into one of the three following categories:

‘None’ indicates that the clause outlines the same requirement(s)/advice as the associated clause resulting in no conflict across documents.

‘Yes’ indicates that the requirement(s)/advice are different resulting in conflict across documents.

‘Potential’ relates to clauses where it is not clear whether there is an actual conflict. While the requirements across the clauses in question relate to similar features, the application is different which may explain the difference(s).

Of the 19 clauses, only three fall into the ‘none’ category, leaving 16 where there is actual or potential conflict across documents. Notwithstanding this, 8 of these conflicts are between TD 40, TD 41 and TD 42 (with the majority of these being between TD 41 and TD 42) which will be resolved if the recommendations made as part of the TD 41 and 42 scoping study\(^1\) are enacted.

This leaves 8 conflicting/potentially conflicting clauses which arise from 3 unique conflicts across the documents. These are discussed in detail in Section 2.2.4.

2.2.4. Conflicts for Discussion

2.2.4.1. Conflict 1 – Curve Widening
This conflict relates to TD 42 Clause 7.25 (Table 7/2) and TD 9 Clause 3.10.

TD 42 Clause 7.25 states that where carriageways are taken around short radius corners, added width shall be provided in accordance with Table 7/2. This table states that for a 100m radius curve, the lane width shall be 3.8m, implying widening of 0.15m per lane (refer to Figure 2-3). TD 9 Clause 3.10 states that for radii between 90m and 150m the lane width shall be increased by 0.3m per lane (refer to Figure 2-4). While TD 9 relates to links and TD 42 relates to junctions, there does not appear to be a logical reason for this conflict, particularly given that Clause 3.12 of TD 9 states that for radii of 90m and less, widening should be in accordance with TA 20 (TA 20 was superseded by TD 42).

In light of the above, it is considered that there is a conflict between TD 9 and TD 42 in relation to what the widening should be for lanes on curves between 90m and 100m.

\(^1\) Highways England Task 481 – TD 41 and 42 Scoping. Refer to Atkins report reference 5139945.70.002: Review of TD 41 & TD 42 (Recommendations Report) for full details.
2.2.4.2. Conflict 2 (potential) – Loop Radii

This potential conflict relates to TD 22 Clause 4.9 (Table 4/2) and TD 40 Clause 6.8 (Table 6/1) and Figures 7/1 to 7/4.

While TD 22 deals with full grade separation and TD 40 deals with compact grade separation, the loop layouts are similar across the documents (refer to Figure 2-5).

TD 22 Clause 4.9 states that minimum loop radii shall be as per Table 4/2. This table indicates that the minimum radius onto all-purpose roads shall be 30m. TD 40 Clause 6.8 states that the radius of compact connector roads (loops) shall be 40m with a relaxation down to 32m being permissible. The 40m radius is repeated on Figures 7/1 to 7/4 of this document (as illustrated in Figure 2-5). The full grade separated all-purpose loops can therefore be of a smaller radius than compact grade separation loops. It should be noted that two way or one way flow has no bearing on the radius of the loops.

In light of the above, it is considered possible that there is a potential conflict between TD 22 and TD 40 in relation to what the minimum radius should be on loops accessing all-purpose roads.
2.2.4.3. Conflict 3 (potential) – Nose Ratio/Hatching Tapers

This potential conflict relates to TD 22 Clause 4.22 (Table 4/3 and 4/4), Clause 4.31 (Table 4/5) and TD 42 Clause 7.30 (Table 7/3).

TD 22 Clause 4.22 states that merge and diverge ‘nose ratios’ shall be as per Table 4/3 and 4/4 of that document. Clause 4.31 (referring to Table 4/5) provides a similar message for forks. TD 42 Clause 7.30 states that tapers for ghost islands and single lane dualling shall be as per Table 7/3 of that document. Although the application and naming convention is different, each table details the ratio of the length to width of hatching designed to direct traffic past similar hazards (refer to Figure 2-6). There is however no correlation between the ratios prescribed across the documents.

At this point it is worth noting how the Traffic Signs Manual (TSM) Chapter 5 deals with hatch marking tapers. This document outlines recommended dimensions for all roads and was last updated in 2003. In this document, there is also a difference between the dimensions prescribed for nosings and physical island/ghost island tapers (as there is between TD 42 and TD 22). While the dimensions for nosings and physical island tapers in TSM Chapter 5 are equivalent to those given in the TD 22, the dimensions for ghost islands in TD 42 and TSM Chapter 5 are not the same.

In summary, both TSM Chapter 5 and DMRB (TD 22 and TD 42) prescribe different dimensions for nosings and physical island/ghost island tapers; however, the reason for this is not clear. In light of the above, it is considered that there is a potential conflict between TD 22 and TD 42 (and TSM Chapter 5) in relation to the nose ratios and tapers for central islands, which are similar features.
2.2.5. **Task Specification Example**

The Task Specification provides an extract from a query relating to conflicting corner radius requirements in TD 42 and TD 40 that has in part driven the commissioning of this study. The extract is copied below:

“A scheme design has raised an issue regarding corner radius values. TD 42/95 clause 7.54 specifies minimum radii of 40m for routes with 120kph design speed and 20m for routes with 85kph design speed while TD 40/94 clause 6.20 specifies curve widening for 40m and 32m radii while clause 6.29 specifies a 20m radius for the channel line without mention of 32m or 40m radii”.

TD 42 Clause 7.54 deals with radii at the end of diverges (refer to Figure 2-7). TD 40 Clause 6.20 deals with the widening of connector roads and refers readers to Table 6/3 for the associated requirements. This table includes details of connector road radii (refer to Figure 2-8)\(^2\). As it can be seen by the figures, the two parameters are not comparable. TD 42 deals with junctions where traffic slows down and turns around a curve from one road into another; whereas TD 40 deals with connector roads where traffic is travelling ahead around a curve albeit at a relatively slow speed. It is therefore considered that there is no conflict between TD 42 and TD 40 in this regard.

TD 40 Clause 6.29 does not provide any information relating to channel radii or more specially a 20m radius. The only mention of a 20m radius in TD 40 is in Figure 6/2. It is therefore assumed that the query detailed in the Task Specification relates to Figure 6/2 rather than Clause 6.29.

For the most part, TD 40 Figure 6/2 does not contradict the requirements of TD 42; however, the figure fails to specify the increased radii of 30m for merges and 40m for diverges where the design speed is 85kph or above. These requirements are outlined in TD 42 Clauses 7.54 and 7.61. Notwithstanding this, the joint proposal of the TD 42 and TD 40 scoping studies is that only the replacement TD 42 RAD will deal with junction requirements in the future, meaning this conflict will be eliminated. The replacement TD 40 will likely deal with requirements for connector roads only.

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\(^2\) It should be noted that the purpose of Table 6/3 is to outline the requirements for curve widening not curve radius. Curve radius requirements are dealt with by TD 40 Clause 6.7 and Table 6/1 specifically.
2.3. Conclusion to the WP2 Analysis

A total of 59 clauses have been identified across TD 9, TD 22, TD 40, TD 41 and TD 42 that provide requirements or advice related to corner radii, horizontal alignment and/or loops.

Of the 59 clauses, 19 are considered to duplicate the requirements/advice of clause(s) in the other documents to some degree. Of these 19 clauses, 16 are considered to provide contradictory or inconsistent information. With this said, half of these conflicts are between the requirements/advice provided in TD 40, 41 and 42 and the recommendations made by the recently completed TD 41 and 42 scoping study\(^3\) will resolve these issues.

This leaves 8 clauses that provide conflicting or potentially conflicting information, which equates to three unique issues. These are detailed in Section 2.4 and summarised below.

- Conflict between curve widening requirements given in TD 42 (Clause 7.25) and TD 9 (Clause 3.10);
- Potential Conflict between loop radius requirements given in TD 22 (Clause 4.9) and TD 9 (Clause 6.8); and
- Potential Conflict between nose ratio/taper requirements given in TD 22 (Clause 4.22 and 4.31) and TD 42 (Clause 7.30).

The example conflict between TD 40 and TD 42 relating to curve radii given in the Task Specification is discussed in Section 2.2.5. Given that the main clauses cited as conflicting deal with non-comparable elements an actual conflict is not considered to exist. Notwithstanding this, TD 40 does duplicate requirements given in TD 42 relating to junction radii. While TD 40 does not provide conflicting requirements it fails to provide information relating to some additional requirements that exist in TD 42. This issue will however be resolved if the recommendations of the TD 41 and 42 scoping study are enacted.

The findings of this study suggests that while there are areas of duplication, conflict or inconsistency across DMRB RADs in relation to corner radii, horizontal alignment and loop requirements/advice, the problem does not appear to be widespread or particularly significant. The majority of issues have already been addressed as part of separate tasks, leaving only three issues outstanding with two of these comprising less serious inconsistencies. These three issues are assessed in further detail in Section 3 along with recommendations for resolving them as part of WP3.

\(^3\) Highways England Task 481 – TD 41 and 42 Scoping. Refer to Atkins report reference 5139945.70.002: Review of TD 41 & TD 42 (Recommendations Report) for full details.
3. Recommendations (WP3)

3.1. WP 2 Findings Meeting

A meeting was held on 28th June 2016 with the Highways England Project Sponsor to discuss the findings of WP2. At the meeting it was agreed that Conflict 1 (curve widening) could be relatively easily resolved by minor alterations to the wording of the curve widening section in TD 9 (refer to Section 3.2 for details); however, due to the more complex nature of Conflicts 2 and 3, it was decided that more in-depth analysis would be required. It was agreed that the production of scale drawings in AutoCAD would be beneficial in understanding the practical differences between the conflicting requirements prior to forming a final recommendation. The further analysis for the loop radius and taper conflicts are set out in Sections 3.3 and 3.4 respectively.

3.2. Conflict 1 – Curve Widening

3.2.1. Conflict Resolution

At the WP2 meeting (see above) it was agreed that to resolve the curve widening conflict TD 9 Clause 3.10 should be changed to state that widening of 0.3m per lane shall be provided for radii greater than 100m up to 150m (instead of 90m to 150m as it currently states). This would eliminate the conflict between TD 9 and TD 42 which currently specify different requirements for widening between 90m and 100m. As TD 42 Clause 7.25 currently states that “for radii greater than 100m, the standards set out in TD 9 shall be used”, no change to TD 42 would be required.

What the above change will mean in practice is that radii currently specified under TD 9 for 90m to 100m will decrease the widening element from 0.3m per lane to 0.15m per lane in the future. This equates to a reduction of 150mm (the width of a typical white line) per lane.

It should be noted that the minimum permitted radius on a mainline in TD 9 is 90m. It would therefore not be sufficient to simply change Clause 3.10 as suggested above without providing advice on the requirements for widening between 90m and 100m. A 90m radius on a trunk road mainline is likely to be rare as it represents a two-step reduction below the desirable minimum for a 50kph design speed. Adding that ‘for radii between 90m to 100m TD 42 shall be used’ to Clause 3.10 is therefore considered an appropriate solution. This is not dissimilar to TD 22, which refers readers to TD 42 for all situations that require curve widening. The solution is also in line with the MDD which states in paragraph 8.5.1 that “RADs shall avoid repetition of information contained in other sources and maximise the use of references”.

In light of the above, it is recommended that TD 9 Clause 3.10 is changed so that widening of 0.3m per lane shall only be provided for radii greater than 100m up to 150m. In addition, reference to TD 42 should be added to Clause 3.10 to capture curve widening for radii between 90m and 100m.

Updating Clause 3.10 as recommended would necessitate changes to Clauses 3.11 and 3.12 also. Clause 3.12 states that radii of less than 90m are departures from standard and for these and all other junction elements widening should be in accordance with TD 42. This clause could simply be deleted. Clause 3.11 would need to be updated in line with the principles of the overarching recommendation for Clause 3.10. Again, this would be relatively straightforward to achieve.

3.2.2. Further Improvements

While changing TD 9 Clause 3.10 as described above would resolve the conflict between TD 9 and TD 42, there is scope to further improve the overarching logic relating to curve widening across the two RADs.

The graph in Figure 3-1 illustrates the curve widening requirements of both TD 42 and TD 9 for increasing curve radii (if the conflict between TD 42 and TD 9 was resolved as recommended above). The orange line represents the actual curve widening for a given radius while the dotted blue line is a curve of best fit. The graphs show that for increasing radii up to 100m (as given in TD 42) the widening per lane decreases steadily; however, this logic does not continue between 100m and 150m as TD 9 prescribes a greater degree of widening. Logic suggests that if a lesser degree of widening is acceptable for a 100m curve, then there would not be any need to provide a greater level of widening between 100m and 150m.
Figure 3-1 shows the lane widening requirements for increasing radii across TD 42 and TD 9. The figure illustrates the actual and curve of best fit for lane widening per lane. The design vehicle is a 16.5m long maximum legal articulated heavy goods vehicle (HGV). The requirements for the widening of substandard width carriageways would need to be altered to suit.

Figure 3-2 shows the swept path analysis of a 100m radius curve with 300mm curve widening per lane and a 100m radius curve with 150mm widening per lane (in both cases the base lane widths are 3.65m). The design vehicle is a 16.5m long maximum legal articulated heavy goods vehicle (HGV). For the 300mm curve widening, there is typically a 1.4m gap between the body envelopes of the vehicles. For the 150mm curve widening, there is typically a 1.1m gap between the body envelopes. As it can be seen from the illustration, there is sufficient room for two HGVs to safely pass one another in both situations.

In light of the above, changing the curve widening requirements in TD 9 to 150mm per lane for carriageways of standard width on curves with radii of between 100m and 150m would appear to be a logical improvement. It is unlikely to have a significant impact on safety but would result in a coherent and economical set of requirements. As part of the update of TD 9, further consideration should therefore be given to changing TD 9 so that it prescribes a minimum curve width of 150mm per lane for standard width carriageways rather than 300mm. As part of this, the requirements for the widening of substandard width carriageways would need to be altered to suit.
Figure 3-2 Comparision of Curve Widening for a 100m Radius Curve in TD 9 and TD 42

100m radius curve with 300mm curve widening per lane

100m radius curve with 150mm widening per lane
3.3. Conflict 2 – Loop Radii

3.3.1. Further Analysis

The TD 22 and TD 40 minimum loop layouts have been drawn to scale in AutoCAD and swept path analysis undertaken in order to better understand the practical differences. It should be noted that unlike TD 40, TD 22 does not permit two-way single carriageway connector roads. While loops designed in accordance with TD 22 can be two way or single way (as required), traffic on full grade separated two way connector roads are required to be separated by a physical central reserve with a vehicle restraint system (TD 22 Clause 5.27). For the purpose of comparing TD 22 and TD 40 loops the central reserve has not been included. The comparison looks at the trafficked pavement widths only.

In TD 22, the minimum loop radius onto all-purpose roads shall be in accordance with Table 4/2 of that document. The associated lane widths are derived from Table 7/2 of TD 42. This gives a loop radius of 30m, an inside lane width of 5.3m and an outside lane width of 5.0m.

In TD 40 the desirable minimum loop radius is 40m. What the overall minimum carriageway width of the loop should be is ambiguous however. Clause 6.23 states that the minimum carriageway width “shall be 6.6m, excluding widening”, yet it is unclear whether widening is a requirement or optional. Clause 6.20 states that “compact connector roads may be widened on curves in accordance with Table 6/3”. While the clause uses the word ‘may’, it is within a black box, which was used in older documents to outline a mandatory requirement. Whether or not widening is required is therefore unclear. The problem is exacerbated by Table 6/3. The heading of the second column states ‘no curve widening’ but a dimension of 0.6m is given for a central hatching i.e. a form of curve widening. The heading of the third column is ‘minimum curve widening’. This gives a dimension of 1.9m for the central hatching on a 40m radius curve. The ambiguity of the wording and table means that there are three different layouts which could be considered the minimum:

A) 40m loop with two 3.3m lanes (no further widening);
B) 40m loop with two 3.3m lanes and a 0.6m wide central hatching; and
C) 40m loop with two 3.3m lanes and a 1.9m wide central hatching.

For the purpose of this study, the above three layouts are referred to as TD 40A, TD 40B and TD 40C respectively. Figures 3-3 to 3-7 are drawings of a 180 degree loop for each of the above plus the TD 22 layout. Figure 3-3 is a scaled side by side comparison of each loop. Figures 3-4 to 3-7 show the ability for the design vehicle (a 16.5m long maximum legal articulated heavy goods vehicle) to negotiate the loops using swept path analysis.

40m is given as the ‘desirable minimum’. This radius is repeated on each of the figures within the document; however, a relaxation down to 32m is permissible but only in “difficult circumstances” (TD 40 Clause 6.8).

The minimum carriageway width is 6.6m. While not explicitly stated, it is assumed that this equates to two 3.3m lanes.

It should be noted that The Traffic Signs Regulations and General Directions (TSRGD) specifies the minimum width of a hatch marking is to be 0.8m (this is the case in both the 2002 and 2016 versions). A 0.6m hatching would therefore not be compliant and is shown here for illustration only.
Figure 3-3  TD 22 and TD 40 minimum loop layouts (each layout is shown proportional to the others)

**TD 22 Minimum Loop onto all-purpose roads:**
- 30m loop radius
- 5.3m inside lane width
- 5.0m outside lane width

**TD 40 minimum Loop A**
- 40m loop radius
- 3.3m lane widths

**TD 40 minimum Loop B**
- 40m loop radius
- 3.3m lane widths
- 0.6m central hatching

**TD 40 minimum Loop C**
- 40m loop radius
- 3.3m lane widths
- 1.6m central hatching
Figure 3-4   TD 22 Minimum Loop Sweptpath analysis
Figure 3-5    TD 40A Minimum Loop Sweptpath analysis
Figure 3-6  TD 40B Minimum Loop Sweeppath analysis
Figure 3-7   TD 40C Minimum Loop Sweptpath analysis
The data obtained from the drawings and swept path analysis is summarised in Table 3-1. The pavement area column indicates the total pavement area for each loop (excluding any hard strips\(^7\)). The footprint column indicates the area of the footprint of each loop which highlights how much land is notionally required to accommodate each layout\(^8\) (Figure 3-8 illustrates how this has been measured). For each parameter the TD 22 loop is taken as the base value for which each other loop is compared to.

**Figure 3-8  Area of loop footprint (defined by the dashed red line)**

<table>
<thead>
<tr>
<th>Loop</th>
<th>Pavement Area</th>
<th>Pavement Difference</th>
<th>Footprint (Land take)</th>
<th>Footprint Difference</th>
<th>Suitability for large vehicles i.e. HGVs</th>
</tr>
</thead>
<tbody>
<tr>
<td>TD 22</td>
<td>1137m(^2)</td>
<td>Base value</td>
<td>3248m(^2)</td>
<td>Base value</td>
<td>Layout will safely accommodate two-way HGV flow with approximately a 2.0m gap between body envelopes.</td>
</tr>
<tr>
<td>TD 40 A</td>
<td>897m(^2)</td>
<td>Approx. 22% smaller</td>
<td>4343m(^2)</td>
<td>Approx. 34% larger</td>
<td>Layout will not safely accommodate HGVs. HGVs will overhang the centreline in both directions.</td>
</tr>
<tr>
<td>TD 40 B</td>
<td>986m(^2)</td>
<td>Approx. 13% smaller</td>
<td>4456m(^2)</td>
<td>Approx. 37% larger</td>
<td>Layout will narrowly accommodate an HGV in one direction only. An HGV will overhang the full width of the central hatching, meaning the layout will not safely accommodate HGVs in both lanes.</td>
</tr>
<tr>
<td>TD 40 C</td>
<td>1181m(^2)</td>
<td>Approx. 4% larger</td>
<td>4705m(^2)</td>
<td>Approx. 45% larger</td>
<td>Layout will accommodate HGVs in both directions; however, there is only approximately a 0.8m gap between body envelopes.</td>
</tr>
</tbody>
</table>

The swept path analysis shows that the TD 40A loop is not suitable for HGVs and therefore not suitable for retention in RADs. In this layout a HGV will straddle the centre line which will increase the risk of head on collisions with vehicles coming the other way. If two HGVs travelling in opposite directions met on this loop they would not be able to pass each other. The TD 40B layout will narrowly accommodate a HGV travelling in one direction however there is little margin for driver error or inaccuracy. Similar to TD 40A, two HGVs travelling in opposite directions around the loop will not physically be able to pass. While TD 40 suggests that this would

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\(^7\) It should be noted that while hardstrips are allowed on connector roads designed to TD 22, they are not permitted to be used on compact connector roads designed to TD 40 (refer to TD 40 Clause 6.26).

\(^8\) In certain cases lesser land areas may be required i.e. an area more closely matching the road shape, or some areas may be given back to landowners. This will be dependent on the acquisition process and the value of non-highway land.
be acceptable in some situations (TD 40 Clause 6.21), such a layout would not be considered acceptable today when applying Highways England’s safe systems approach.

The TD 40C layout will accommodate HGVs travelling past each other on the loop with approximately a 0.8m gap between the body envelopes of the vehicles. The TD 22 layout will accommodate HGVs in both directions but there would be approximately a 2.0m gap between body envelopes. The TD 22 loop and associated pavement width is therefore the most suitable to accommodate all traffic types.

Layout TD 40C has the largest pavement area of the loops and also the largest footprint area. While TD 40A and TD 40B have slightly smaller paved areas, the footprints of these loops are significantly larger than the TD 22 layout.

### 3.3.2. Other Considerations

#### 3.3.2.1. Connector Road Gradients

With a smaller radius, a greater gradient will be required across the loop to transition traffic from mainline level to minor road level. As the TD 22 loop is smaller, it is important to ascertain whether a potential decrease in loop size for a compact connector road would adversely impact on the gradient requirements.

TD 27 indicates that the worst case headroom required for new overbridges is 5.38m (derived from Table 6-1 and 6-2 of TD 27). Adding a reasonable amount for bridge deck depth gives an approximate rise from major road level to minor road level of 6.0m.

Figure 3-9 illustrates the smallest likely loop configuration for a compact grade separated junction i.e. a 90 degree loop. If the junction remains at grade on each side of the loop and the gradient is applied over the 20m straights and the 30m radius, the full height difference would need to be achieved over approximately 87m.

Rising by 6.0m over an 87m length gives a 6.90% gradient. TD 40 Clause 6.15 states that the maximum gradient for compact connector roads shall be 8%, although a relaxation to 10% is permitted in “difficult locations”. This assessment is based on the junction of the local road and the connector road being at the same level as the bridge carriageway. In some situations the local road may be on a gradient which results in the level difference between the main road and the local road/main road junction being greater than 6.0m. In order to not to exceed the 10% maximum connector road gradient, the maximum level difference could be 8.7m. Level difference greater than this will require alterations to the geometry and/or position of the connector road junctions, which is part of the normal design process and might result in a decision to provide a greater curve radius than 30m.

It light of the above it is considered unlikely that a reduction to a 30m minimum radius from a 40m minimum radius would cause problems with connector road gradients.

**Figure 3-9** TD 40 standard loop dimensions

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87m is approximately the length of a 90 degree 30m radius arc plus 2x20m straights.
3.3.2. Vehicle Speeds

The ability for vehicles to safely travel around the curve is also an important consideration. With a 30m radius, vehicles will need to travel slower around the curve or they may leave the carriageway or cross over into the opposing lane. A concern could be that with a smaller radius, the loop would be less “forgiving” if road users approach at speed.

For compact grade separated junctions, the loop will typically be preceded by a smaller 20m radius curve at the end of the diverge lane or at the priority T-junction connecting to the minor road (refer to TD 40 Figure 6/2). In such situations it will not be possible for traffic to enter the loop too fast given the tighter radius they will have encountered just prior. This is acknowledged in TD 40 paragraph 6.4: “As a general principle it is intended that the speed of vehicles through the compact connector road shall be limited by its speed through the entry and exit junctions with the mainline and the minor road.” It could also be argued that a smaller loop radius would be beneficial for road users approaching the smaller 25m merge section radius or the give-way line at the top of the loop.

Notwithstanding the above, there are some layouts illustrated in TD 40 where the connector road loop is not preceded by a smaller 20m radius. In such situations, traffic may approach the loop at higher speeds; however, this is no different from the junction layouts already prescribed by TD 22. In such situations it is up to the designer to determine whether further mitigation may be necessary e.g. sharp deviation of route signs.

3.3.2.3. Sinuosity

Reducing the radius of connector road loops will make the resultant road layouts more sinuous. The ability for the design vehicle to negotiate a more sinuous layout has therefore been tested using swept path analysis for the design vehicle (a 16.5m long maximum legal articulated heavy goods vehicle) to determine the impact. The road layout shown in Figure 3-10 below has been drawn in accordance with the requirements of TD 40 with the exception of the connector road radius. This has been reduced to 30m and widened in accordance with TD 22. The figure shows that while the road layout is more sinuous, the design vehicle does not experience any particular difficulties turning through it. Fundamentally, it is the 20m straight between curves that allows drivers time to straighten up before turning in the opposite direction and it is not proposed to alter this aspect of the requirements.

Figure 3-10 Ability for the design vehicle to negotiate a more sinuous layout
3.3.2.4. TD 40 Relaxation below Desirable Minimum

TD 40 Clause 6.8 states that the desirable minimum loop radius of 40m should be used in “normal circumstances”; however, a relaxation of one design step to 32m may be used in “difficult circumstances”. Hence the designer could justify use of a 32m loop radius. In some situations therefore the loop radius of a TD 40 layout may only be 2m different to that of a TD 22 layout.

3.3.2.5. TD 40 Preparation Report - Bullen Consultants

Bullen Consultants drafted TD 40/94. As part of this work Bullen produced a report (dated February 1995) that summarises the research undertaken to inform the TD 40 design parameters selected. This report has been reviewed in an attempt to ascertain the reasoning behind the selection of 40m as the minimum loop radius.

Horizontal radius is discussed in paragraphs 5.2.40 to 5.2.44 of the Bullen report. No explicit reasoning for selecting 40m is given; however, the potential reasoning is hinted at. Figure 3-11 below shows an extract of the Bullen report. To the right of the image the loop radii table from TD 22/92 is included. This table indicates that the radius shall be 30m for loops onto the mainline and 50m for loops off the mainline. As these radii are for one way flow and connector roads for TD 40 are two way flow (i.e. both on and off the mainline), it is possible that Bullen simply selected the middle value for two-way compact connector roads i.e. 40m.

Figure 3-11 Extract of the Bullen Consultants Report

3.3.3. Summary and Recommendation

The findings of this further analysis are summarised as follows:

A) The 30m radius TD 22 layout is the most suitable for catering for larger vehicles;

B) The 30m radius TD 22 layout has the smallest land footprint;

C) The overall pavement area of the 30m radius TD 22 layout is smaller than the only TD 40 layout that is capable of catering for two-way HGV flow;

D) A radius reduction from 40m to 30m will have limited impact on the risk of vehicles travelling too fast around the loop, owing to the fact that users typically have to slow down for a 20m radius immediately prior to a compact loop;

E) Following on from D), slower speeds around the loop enforced by a tighter radius may actually be favourable given the smaller upstream and downstream radii that feature as part of compact grade separated layouts;

F) A reduction from 40m to 30m will result in steeper gradients where the minimum radius is used, however it is unlikely to prevent current maximum connector road gradient requirements being met. In difficult situations a larger radius could still be used if necessary as part of the normal design process;

G) A reduction from 40m to 30m is not significantly less than the permitted relaxation already given in TD 40 which allows a 32m loop in “difficult circumstances”;
H) A review of the report produced to justify the design parameters selected for TD 40 has not highlighted any specific reasoning for selecting a 40m radius other than it potentially being a reasonable median between the loop radii of 30m and 50m specified for full grade separated junctions; and

I) TD 22 was last updated in 2006 whereas the current TD 40 was published 1994. TD 22 loop requirements therefore represents the most up-to-date thinking.

In light of the above, it is recommended that the minimum loop radius for compact connector roads in TD 40 is reduced from 40m to 30m with no permitted relaxations. Given the ambiguity of the curve widening requirements in TD 40, it is also recommended that the TD 22 approach for dealing with curve widening is adopted i.e. simply referring readers to TD 42.

While central hatching is not mentioned in TD 22 (given that two way connector roads to TD 22 are required to be separated by a vehicle restraint system), this is fundamentally a best practice measure to aid driver positioning. The decision whether or not to provide hatching should therefore be left to the designer on a site by site basis.

### 3.4. Conflict 3 – Nose Ratio/Hatching Tapers

#### 3.4.1. Further Analysis

The variety of nose ratios/hatching tapers (herein refereed to simply as tapers) specified in TD 22, TD 42 and also TSM Chapter 5 have been drawn to scale in AutoCAD. Similar to Conflict 2, these drawings have been produced to assist in understanding the practical differences between layouts. The drawings are contained in Appendix C.

Tapers can be developed either symmetrically about the road centre line or entirely on one side of the centre line (this is illustrated in Figure 3-12 below). Depending on how the marking is specified, the ratio of length to width may not always be representative of the actual deflection that will be experienced. For comparative purposes, it is more useful to consider the angle of deflection rather than the ratio of length to width.

*Figure 3-12  Tapers developed symmetrically (left) and entirely to one side of the centre line (right)*

The tapers specified across the documents are often intended for different applications e.g. merges/diverges, ghost islands, single lane dualling arrangements or simply for deflecting vehicles past a single traffic island. While in some cases the length of a taper will be based on additional considerations e.g. gap finding at merges where traffic needs to move over into an adjacent lane (this is discussed further in Section 3.4.2), the majority of tapers are used to move traffic around an obstacle. The design speed is the overarching parameter that determines what minimum taper will achieve a safe manoeuvre. From first principles it would seem logical that the deflection angle for a particular design speed would be consistent for these tapers; however, as established in WP2, this is not the case.

Table 3-2 details the angle of deflection for each taper specified in TD 22, TD 42 and TSM Chapter 5 for each design speed. Section 3.4.2 provides analysis of this table. It should be noted that the shallower the angle, the less deflection there is. Taper ratios are specified as minimums across each of the aforementioned documents. This is because the smaller the taper ratio, the greater the deflection. If the documents specified tapers in angles, they would need to be specified as maximum angles.
Table 3-2  Taper Comparison (maximum permitted angles for given design speeds)

<table>
<thead>
<tr>
<th>Design Speed / Speed Limit</th>
<th>Merging Tapers (moving in past the nosing/hatching)</th>
<th>Diverging Tapers (moving out past the nosing/hatching)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TD 22</td>
<td>TD 42</td>
</tr>
<tr>
<td></td>
<td>Angle</td>
<td>Element</td>
</tr>
<tr>
<td>Motorway</td>
<td>1.43°</td>
<td>Merge</td>
</tr>
<tr>
<td>120kph / 70mph</td>
<td>1.89°</td>
<td>Rural AP Merge</td>
</tr>
<tr>
<td>All other</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M’way Interchange</td>
<td>2.29°</td>
<td>Merge</td>
</tr>
<tr>
<td>100kph / 60mph</td>
<td>2.29°</td>
<td>Rural AP merge</td>
</tr>
<tr>
<td>All other</td>
<td></td>
<td></td>
</tr>
<tr>
<td>85kph / 50mph</td>
<td>2.29°</td>
<td>Rural AP merge</td>
</tr>
<tr>
<td>All other</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60/70kph / 40mph</td>
<td>2.29°</td>
<td>Rural AP merge</td>
</tr>
<tr>
<td>All other</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50kph / 30mph</td>
<td>2.29°</td>
<td>Rural AP merge</td>
</tr>
<tr>
<td>All other</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.4.2. Analysis of Angles from Table 3-2

While there are similarities i.e. the angles for nosings and physical island tapers in TSM Chapter 5 are equivalent to those given in TD 22, there are still a variety of different tapers specified across the documents for the same design speeds. The variance of which increases as the design speed decreases. The reason for this is that at lower design speeds there is an increased number of purposes for which a taper can be introduced. In the worst case (40mph and 30mph design speeds), there are six different taper angles specified across the documents for the same design speed.

It is acknowledged that in some situations tapers for merging and diverging may need to be different. An example of this is a slip road merge onto the mainline of a dual carriageway. In this situation a longer merge nose and therefore a shallower taper angle may be preferable to afford drivers additional time to assess mainline traffic in their mirrors before moving over. In consideration of this, the table does show that diverge taper angles are typically greater than or the same as merge taper angles for equivalent features. Notwithstanding this, in the worst case there are still five different angles specified for both merges and diverges for a given design speed. In some situations the angles specified can differ by a factor of almost four. What this means in reality is that motorists could experience deflection up to four times greater for the same design speed across sections of the trunk road network depending on which document has been used to determine the tapers provided.

There also appears to be little consistency moving between design speeds. The angle and therefore level of deflection fluctuates up and down. In some cases the angles specified for a 30mph or 40mph speed are shallower than that specified for motorways and 70mph all-purpose roads. This suggests that in some cases a greater level of deflection is acceptable on a 70mph road than a 30mph road albeit traffic typically travelling over twice as fast on the former. Although the differences are driven by road type and are reflective of available development space, road users are likely to modify behaviour in response to posted speed limit. If the posted limit follows the design speed then these differences in taper layout are likely to be noticeable.

3.4.3. Summary and Recommendation

The additional analysis, and in particular Table 3-2, shows the level of inconsistency between tapers specified for particular design speeds across the documents. There seems to be no particular pattern or rationale that can be deduced to suggest that the tapers specified in one particular document are more suitable than those given in another. While there is likely to be further reasoning why a taper specified for a given design speed may need to be different for certain situations (refer to Section 3.4.2), the level of inconsistency prevents it from being clear where this rationale could have been applied.

In order to determine what tapers are actually suitable for a given design speed, further research would be required that is beyond the scope of this task. This research could comprise off-road testing in order to assess the ability for vehicles to cope with varying levels of deflection from first principles. The initial testing could be used to identify whether it is actually possible for the test vehicle to remain 'in lane' while passing varying taper angles at varying speeds. Tools such as gyroscopes and accelerometers could then be used to assess the degree of impact that passing the tapers has in order to determine a bench mark or ‘safe minimum’ taper for each design speed. This bench mark angle could then be altered for any application where further factors need to be taken into account e.g. merge noses as described previously.

Notwithstanding the above, while there is clearly some level of inconsistency across the documents, there is no evidence to suggest that this is causing any particular safety issues on the network. While leaner and more aligned taper requirements could be developed by undertaking further research, the cost of undertaking it might not represent value for money. Furthermore, in some cases as described previously, different requirements are likely to be required for merge tapers where traffic is moving from one lane into another.

In light of the above, it is recommended that consideration is given as to whether the inconsistencies in taper lengths across the document represent a significant issue that justifies further investigation. If the decision is taken that further research is required, off-road tests would represent a safe and suitable method of determining a consistent set of requirements for taper angles.
3.5. **Summary of Recommendations**

Of the three conflicts identified as part of WP2, it has been possible to provide a recommendation that will remove the inconstancy relating to two of these (Conflict 1 – Curve Widening and Conflict 2 – Loop Radii). Given the nature of the conflicts and the further research undertaken (as applicable), these recommendations have been made with high a level of confidence.

It has however not been possible within the scope of this task to provide a recommendation to resolve Conflict 3 - Nose Ratio/Hatching Tapers. The level of inconsistency and lack of any apparent rational for this means that further research will be required to resolve the conflict (if this is deemed important).

A summary of the recommendations made as part of this WP is given in Table 3-3 along with the clauses effected by them.

**Table 3-3  Summary of WP3 Recommendations**

<table>
<thead>
<tr>
<th>Conflict</th>
<th>Recommendation</th>
<th>Affected Clauses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Curve Widening</td>
<td>Change TD 9 Clause so that widening of 0.3m per lane shall only be provided for radii greater than 100m up to 150m. For Radii between 90m to 100m, TD 42 shall be used.</td>
<td>TD 9 Clause 3.10, 3.11 and 3.12.</td>
</tr>
<tr>
<td></td>
<td>The recommendation above resolves the conflict; however it is recommended that consideration is also given to changing TD 9 so that it prescribes a minimum curve widening width of 150mm per lane for standard width carriageways rather than 300mm. As part of this, the requirements for the widening of substandard width carriageways would need to be altered to suit.</td>
<td>TD 9 Clause 3.10, 3.11 and 3.12.</td>
</tr>
<tr>
<td>2 – Loop Radii</td>
<td>Reduce the minimum loop radius for compact connector roads in TD 40 from 40m to 30m with no permitted relaxations.</td>
<td>TD 40 Figure 1/1, Table 6/1, Table 6/3 and Figure 7/1 to Figure 7/4.</td>
</tr>
<tr>
<td></td>
<td>It is also recommended that the TD 22 approach for dealing with curve widening is adopted in TD 40 i.e. simply referring readers to TD 42. This would be a marked improvement as the current curve widening requirements in TD 40 have been noted to be somewhat ambiguous.</td>
<td>TD 40 Clause 2.3 e., 3.10, 6.20 to 6.23, Figure 6/1, Table 6/3 and Table 6/4.</td>
</tr>
<tr>
<td>3 – Nose Ratio/ Hatching tapers</td>
<td>Consider whether the inconsistencies in taper lengths across documents represents a significant issue that justifies further investigation. If the decision is taken that further research is required, off-road tests would represent a safe and suitable method of investigation.</td>
<td>To be determined.</td>
</tr>
</tbody>
</table>
Appendix A. Line by Line Review Table
**TD 22 2.32 Merge Dimensions**

The minimum width of a ghost island is 2.0m at its widest point and the minimum width of a chevron is 0.5m (TSRGD diagram 1042.1). If the ghost island marking is less than 1.2m wide it will be too narrow to mark with chevrons. The length of ghost island that is unmarked with chevrons could extend over a long distance. In order to prevent this problem, the minimum width of a ghost island must be 1.2m at a distance of 50m from the tip of the ghost island head or tail. It should be noted that ghost island layouts can require significant length to comply with the standard and this may be reflected in the land requirement especially where the layout is being provided within an existing highway boundary.

<table>
<thead>
<tr>
<th>Clause Text</th>
<th>Duplication/Conflict</th>
<th>MDD Comments</th>
<th>General Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) &quot;The minimum width of a ghost island is 2.0m at its widest point,&quot;</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>b) &quot;The minimum width of a ghost island must be 1.2m at a distance of 50m from the tip of the ghost island head or tail.&quot;</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

1. The meaning of requirement A is not obvious. It is assumed it means that the hatching needs to be at least 2.0m wide at some point along its full length.
2. "ghost island" is more commonly used to describe other features. The feature being discussed is hatching. Colloquially it is referred to as a tiger tail.

**TD 22 2.34 Merge Near straight**

Gap finding is assisted when the merging traffic has the opportunity to match the speed of the mainstream traffic. For all connector roads, a near straight at least equal in length to the nose length given in Table 4/3 column (3) for the appropriate Road Class must be provided downstream of the back of the merge nose. This requirement will enable merging traffic to achieve a matching speed.

<table>
<thead>
<tr>
<th>Clause Text</th>
<th>Duplication/Conflict</th>
<th>MDD Comments</th>
<th>General Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

1. The first and last sentences give the same message, although both are superfluous.

**TD 22 2.46 Diverge Near straight**

For all connector roads, a near straight at least equal in length to the nose length given in Table 4/4 column (4) for the appropriate Road Class must be provided downstream of the back of the diverge nose. This requirement will enable drivers to comprehend the layout and adjust their speed accordingly.

<table>
<thead>
<tr>
<th>Clause Text</th>
<th>Duplication/Conflict</th>
<th>MDD Comments</th>
<th>General Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

1. The last sentence is superfluous

**TD 22 2.53 Ghost Island Dimensions**

The minimum width of a ghost island is 2.0m at its widest point and the minimum width of a chevron is 0.5m (TSRGD diagram 1042.1). If the ghost island marking is less than 1.2m wide it will be too narrow to mark with chevrons. The length of ghost island that is unmarked with chevrons could extend over a long distance. In order to prevent this problem, the minimum width of a ghost island must be 1.2m at a distance of 50m from the tip of the ghost island head or tail. It should be noted that ghost island layouts can require significant length to comply with the standard and this may be reflected in the land requirement especially where the layout is being provided within an existing highway boundary.

<table>
<thead>
<tr>
<th>Clause Text</th>
<th>Duplication/Conflict</th>
<th>MDD Comments</th>
<th>General Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) &quot;The minimum width of a ghost island is 2.0m at its widest point,&quot;</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>b) &quot;The minimum width of a ghost island must be 1.2m at a distance of 50m from the tip of the ghost island head or tail.&quot;</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

1. This clause, while not duplicated in another RAD, is identical to TD 22 Clause 2.32.
2. Refer to Clause 2.32 comments

**TD 22 4.5 Transition Curve Design Speed**

Any transition curves at all locations where the design speed changes must be designed to the higher design speed value.

<table>
<thead>
<tr>
<th>Clause Text</th>
<th>Duplication/Conflict</th>
<th>MDD Comments</th>
<th>General Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

1. Inappropriate use of "must" in the fourth sentence.

**TD 22 2.46 Diverge Edge line radii**

For diverses, the layout of the edge line must incorporate the radii shown on Figure 2/6.

<table>
<thead>
<tr>
<th>Clause Text</th>
<th>Duplication/Conflict</th>
<th>MDD Comments</th>
<th>General Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

1. Inappropriate use of "must" in the second sentence.

**TD 22 4.5 Transition Curve Design Speed**

Any transition curves at all locations where the design speed changes must be designed to the higher design speed value.

<table>
<thead>
<tr>
<th>Clause Text</th>
<th>Duplication/Conflict</th>
<th>MDD Comments</th>
<th>General Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

1. Inappropriate use of "must" in the fourth sentence.

**TD 22 4.5 (Table 4/2) Loops**

To facilitate road marking, loops must be related to curves in accordance with TD 9 (DMRB 6.1.1) and TD 42 (DMRB 6.2.6).

<table>
<thead>
<tr>
<th>Clause Text</th>
<th>Duplication/Conflict</th>
<th>MDD Comments</th>
<th>General Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

This clause is in effect an extension of Clause 4.5 which refers back to TD 9.

**TD 22 4.5 Transition Curve Design Speed**

Any transition curves at all locations where the design speed changes must be designed to the higher design speed value.

<table>
<thead>
<tr>
<th>Clause Text</th>
<th>Duplication/Conflict</th>
<th>MDD Comments</th>
<th>General Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

This clause is in effect an extension of Clause 4.5 which refers back to TD 9.

**TD 22 4.5 Transition Curve Design Speed**

Any transition curves at all locations where the design speed changes must be designed to the higher design speed value.

<table>
<thead>
<tr>
<th>Clause Text</th>
<th>Duplication/Conflict</th>
<th>MDD Comments</th>
<th>General Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

This clause is in effect an extension of Clause 4.5 which refers back to TD 9.

**TD 22 4.5 Transition Curve Design Speed**

Any transition curves at all locations where the design speed changes must be designed to the higher design speed value.

<table>
<thead>
<tr>
<th>Clause Text</th>
<th>Duplication/Conflict</th>
<th>MDD Comments</th>
<th>General Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

This clause is in effect an extension of Clause 4.5 which refers back to TD 9.
<table>
<thead>
<tr>
<th>Doc. Clause</th>
<th>Subject</th>
<th>Parameter</th>
<th>Clause Text</th>
<th>Extracted Requirement/Advice</th>
<th>Duplication/Conflict (across RADs)</th>
<th>MDD Comments</th>
<th>General Comments</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>TD 22 4.13 Loops</td>
<td>SSD / Widening</td>
<td></td>
<td>The findings give support to the argument that average speed of approach to a loop may have an impact on its safety record. It is possible that the higher speeds on motorways on the approach to loops may be a contributory factor to accidents, particularly on diverge loops. Measures to maintain safety are necessary, and measures to consider include: (i) provision and maintenance of clear visibility over the whole of the loop on the approaches, especially beyond an underbridge (see paragraph 4.19); (ii) widening of lanes on the loops as appropriate for lower radii in accordance with TD 42 (DMRB 6.2.6);</td>
<td>A) Considering maintenance visibility over the entirety of the loop.</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>TD 22 4.19 Loops</td>
<td>SSD</td>
<td></td>
<td></td>
<td></td>
<td>A) Consider maintaining visibility over the entirety of the loop.</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>TD 22 4.22 Merge Radii</td>
<td>Merge / Diverge Nose ratio</td>
<td></td>
<td></td>
<td>A) For merges, the use of large radii is not required for the edge line.</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>TD 22 4.22 Merge Radii</td>
<td>(Table 4/3 &amp; 4/4)</td>
<td></td>
<td>Merge and diverge lane nose ratios/ratios must be as per Table 4/3 and 4/4</td>
<td>Potential</td>
<td>Potential</td>
<td>TD 42</td>
<td>7.30 (Table 7/3)</td>
<td>1) Inappropriate use of 'must'</td>
</tr>
<tr>
<td>TD 22 4.28 Mainline Radii</td>
<td></td>
<td></td>
<td></td>
<td>A parallel merge / diverge must be used if the mainline radii is below the desirable minimum in TD 9.</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>TD 22 4.31 Fork</td>
<td></td>
<td></td>
<td>A 1:12 nose ratio must be used for a fork with an interchange link</td>
<td>Potential</td>
<td>Potential</td>
<td>TD 42</td>
<td>7.30 (Table 7/3)</td>
<td>1) Inappropriate use of 'must'</td>
</tr>
<tr>
<td>TD 22 5.28 ERTs Radii</td>
<td></td>
<td></td>
<td>ERT 8 should not be positioned on the inside of connector roads with radii below desirable minimum on motorway interchanges.</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>1) as vehicles have been observed to move into the hardshoulder on such sections’ is superfluous. 2) ERT positioning is potentially outside the scope of TD 22.</td>
</tr>
<tr>
<td>Doc</td>
<td>Clause</td>
<td>Subject</td>
<td>Parameter</td>
<td>Clause Text</td>
<td>Extracted Requirement/Advice</td>
<td>Duplication/Conflict</td>
<td>MDQ Comments</td>
<td>General Comments</td>
</tr>
<tr>
<td>-----</td>
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<td>-----------</td>
<td>-------------</td>
<td>----------------------------</td>
<td>---------------------</td>
<td>--------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>TD 40</td>
<td>6.10</td>
<td>Signs</td>
<td>Curve widening</td>
<td>Where full curve widening is not provided, as identified by paragraphs 6.20, 6.21 and Table 6/3, then regulatory signs shall be provided in accordance with Chapter 3 of the Traffic Signs Manual on the compact connector road to advise motorists in one direction that they should give way to vehicles proceeding in the opposite direction. Statutory requirements for regulatory signs are contained in the Traffic Signs Regulations and General Directions and Traffic Signs Regulations (Northern Ireland).</td>
<td>A) Minimum carriageway width of a compact connector road shall be between 6m to 7.9m (excl. Widening).</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>TD 40</td>
<td>6.18</td>
<td>Compact connector roads</td>
<td>Super-elevation</td>
<td></td>
<td>A) Junction entries and exits with the mainline shall be based upon the standards contained within TA 20 (DMRB 6.2) modified to remove the right turn manoeuvres associated with the mainline traffic. Right turn manoeuvres will effectively be relocated at the priority junctions on the minor road.</td>
<td>A) Junction entries/entries to be designed in accordance with TA 20.</td>
<td>None</td>
<td>NA</td>
</tr>
<tr>
<td>TD 40</td>
<td>6.20</td>
<td>Compact connector roads</td>
<td>Radii</td>
<td>Left in left out junction details</td>
<td>A) Minimum carriageway width of a compact connector road shall be between 6m to 7.9m (incl. Widening). B) Relaxation to 6m permitted for low usage by large vehicles and the probability of them meeting on the curve.</td>
<td>A) 20m inner radius for left in left out junctions. B) island corner radii to be 0.7m to 1.0m</td>
<td>In principle</td>
<td>Yes</td>
</tr>
<tr>
<td>TD 40</td>
<td>6.27</td>
<td>Compact connector roads</td>
<td>Reference</td>
<td>Junction entries and exits with the mainline shall be based upon the standards contained within TA 20 (DMRB 6.2) modified to remove the right turn manoeuvres associated with the mainline traffic. Right turn manoeuvres will effectively be relocated at the priority junctions on the minor road.</td>
<td>A) Junction entries/entries to be designed in accordance with TA 20.</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>TD 40</td>
<td>6.29</td>
<td>Compact connector roads</td>
<td>Reference</td>
<td>Neaside diverging and merging tapers shall be provided in accordance with the directions given in TA 20 (DMRB 6.2).</td>
<td></td>
<td></td>
<td>None</td>
<td>NA</td>
</tr>
<tr>
<td>TD 40</td>
<td>7.1</td>
<td>Geometry</td>
<td>Radii</td>
<td>Example of compact grade separation</td>
<td>40m loop radius shown all layouts (Table 22 Table 6/1 states that the 40m may be relaxed to 32m. Both 40m and 32m shall have 5% super elevation)</td>
<td>Potential</td>
<td>Potential</td>
<td>TD 22 Table 4-2</td>
</tr>
<tr>
<td>TD 40</td>
<td>8.8</td>
<td>Compact connector roads</td>
<td>Radial</td>
<td>Horizontal radii shall comply with Table 6/1. In normal circumstances the Desirable Minimum Radius should be used, however in difficult circumstances a Relaxation of one design speed step may be used at the discretion of the Design Organisation.</td>
<td>A) 40m desirable min radii with 5% super elevation. B) 32m relaxation of one design speed step with 5% super elevation.</td>
<td>Potential</td>
<td>Potential</td>
<td>TD 22 Table 4-2</td>
</tr>
<tr>
<td>TD 40</td>
<td>8.9</td>
<td>Compact connector roads</td>
<td>Transition curves</td>
<td>Given the low design speed and the nature of the compact connector road, transition curves are not required within the compact grade separated junction.</td>
<td></td>
<td>As Clause text</td>
<td>None</td>
<td>NA</td>
</tr>
<tr>
<td>TD 40</td>
<td>8.18</td>
<td>Compact connector roads</td>
<td>Super-elevation</td>
<td>Super-elevation on compact connector roads shall be limited to 5% approximate.</td>
<td>As Clause text</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

**MDD Comments**

1. It is not clear what signs this clause is referring to. TSM Chapter 3 deals with a great variety of sign types.
2. This clause directly relates to Clauses 6.20 but is located in a different part of the document. It is also partial repetition of Clause 6.20.
3. The last sentence is superfluous.
In principle None TD 41 Layout 3 1) For MDD comments refer to TD 41/42

A) Recommended min radius at simple junctions is 6m for urban and 10m for rural where no provision is made for HGVs.

B) Where provision is made for HGV refer to clause bullet.

**Doc Notes**

- **Extracted Requirement/Advice Duplication/Conflict (across RADs)**
- **Clause Subject Parameter Clause Text MDD Comments General Comments**

**TD 42 7.17 Geometry Radii**

Where no provision is made for large goods vehicles, it is recommended that the minimum circular corner radius at simple junctions should be 6m in urban areas and 10m in rural areas. Where provision is to be made for large goods vehicles, the recommended circular corner radius is:

- a. 10m at urban simple junctions, followed by a taper of 1:5 over a distance of 30m, measured from the edge of the major road carriageway up the minor road in the case of the entry to the minor road, and followed by a similar taper measured from the centreline of the minor road along the major road for the entry to the major road.
- b. 15m at rural simple junctions, with tapers of 1:10 over a distance of 25m.
- c. 15m at ghost island junctions, with tapers of 1:6 over a distance of 30m.
- d. 15m at staggered junctions, with tapers of 1:8 over a distance of 32m.
- e. 20m radius in all other circumstances.

These radii only apply where there are no nearside diverge taps or lanes, or nearside merge taps. Figures for these are given in para 7.54 and 7.61 respectively.

**In principle** Yes TD 41 Layout 3 1) For MDD comments refer to TD 41/42 1) The last sentence is almost identical to TD 41 Layout 3 text, except in TD 42 the use of a compound curve is recommended, rather than mandated as per TD 41. Notwithstanding this, recommendations made as part of the TD 41/42 scoping study will resolve this issue

**TD 42 7.18 Geometry Radii**

Where large goods vehicles comprise a significant proportion of the turning movements, use of the compound curve shown in Fig 7/3 is recommended.

Where large goods vehicles comprise a significant proportion of the turning movements, use of the compound curve is recommended. In principle Yes TD 41 Layout 3 1) For MDD comments refer to TD 41/42 1) i) It is unlikely these radii will be carried over to the updated RAD.

**TD 42 Fig 7/5 Geometry island radii**

Major / Minor Priority Junctions with Single Lane Dualling

8m radius and 22m radius shown None NA NA NA 1) For MDD comments refer to TD 41/42

Recommended that the minimum circular corner radius at simple staggered junctions, with tapers of 1:8 over a distance of 32m.

**TD 42 Fig 7/6 Geometry island radii**

Dual Carriageway Major/Minor Priority Junction

26m Radius and 28m radius shown None NA NA NA 1) For MDD comments refer to TD 41/42

**TD 42 7.25 /Tab 7/2 Geometry Curve widening**

Where carriageways are taken around short radius corners, added width shall be provided to cater for the swept area of larger goods vehicles and the "cut in" of trailer units. On single lane sections greater than 50m in length an allowance shall be made for broken down vehicles as in para 7.41. Table 7/2 shows the recommended minimum widths for various nearside corner radii based on the design vehicle. For radii above 100m, the standards set out in TD 9 (OM9S 6.11) shall be used.

**A) 8m curve width shall be as per Table 7/2.**

Where no provision is made for large goods vehicles, it is recommended that the minimum circular corner radius at simple junctions is 6m for urban and 10m for rural where no provision is made for HGVs.

**In principle** None TD 41 Layout 3 1) For MDD comments refer to TD 41/42 1) Potential Potential TD 22 4.22 (Table 4/3 and 4/4) and 4.31 (Table 4/5) 1) The TD 41/42 scoping study highlighted the difference between TD 42 L2 and TSM Chapter 5 tapers. One of the recommendations to be investigated whether it is possible to retain less onerous requirements for SDL and ghost islands with a view to deleting this and only showing tapers equivalent to current dual carriageway lengths (as per tapers in TSM Chapter 5).

**B) Widening of curves with radii over 100m shall be as per TD 9.**

**TD 42 7.30 (Table 7/3) Tapers Island tapers**

Central islands, whether for ghost islands (Fig 7/8) or single lane dualling (Fig 19) should normally be developed symmetrical about the centreline of the major road to their maximum width at the apex shown in Table 7/3. The maximum island width should continue through the junction to the tangent point of the minor road radius and the edge of the major road carriageway.

For single lane dualling, the central island should be introduced by means of hatched markings until there is sufficient width to accommodate the appropriate sign on the nose of the physical island with the required running clearances to it.

**A) Various taper ratios based on differing design speeds**

**Potential** Potential TD 22 4.22 (Table 4/3 and 4/4) and 4.31 (Table 4/5) 1) The TD 41/42 scoping study highlighted the difference between TD 42 L2 and TSM Chapter 5 tapers. One of the recommendations to be investigated whether it is possible to retain less onerous requirements for SDL and ghost islands with a view to deleting this and only showing tapers equivalent to current dual carriageway lengths (as per tapers in TSM Chapter 5).

**B) Min curve widths shall be as per Table 7/2.**

**TD 42 7.35 Ghost Island Width**

For new junctions, the desirable width of a ghost island turning lane shall be 3.5m, but a Relaxation to 3.0m is permissible. At urban and suburban junctions it can sometimes be advantageous to use a greater width not exceeding 5.0m to allow a degree of shelter in the centre of the road for large goods vehicles turning right from the minor road to execute the turn in two separate manoeuvres. On rural roads, with design speeds above 85km/h or where hardshoulders are present, widths greater than 3.56m are inadvisable because wide ghost islands in these situations create a sense of space that could encourage hazardous overtaking at junctions.

**Potential** Potential NA NA NA 1) For MDD comments refer to TD 41/42 1) Notwithstanding the above, this study has highlighted another potential issue. While TD 22 Table 4/3, 4/4 and 4/5 deals with tapers at merges and diverses and TD 42 Table 7/3 deals with tapers at dual carriageways / SDL, all tapers are for hatching leading to a physical island. With this in mind the ratios are significantly different. This could be argued to be a potential conflict

**TD 42 7.36 Ghost Island Width**

For improvements to existing junctions where space is very limited a reduced width may be unavoidable. The width of ghost islands shall not be less than 2.5m.

**A) At existing junctions 2.5m min width is allowed**

**Potential** Potential NA NA NA 1) For MDD comments refer to TD 41/42 1) Notwithstanding the above, this study has highlighted another potential issue. While TD 22 Table 4/3, 4/4 and 4/5 deals with tapers at merges and diverses and TD 42 Table 7/3 deals with tapers at dual carriageways / SDL, all tapers are for hatching leading to a physical island. With this in mind the ratios are significantly different. This could be argued to be a potential conflict.
### TD 42 7.54 Diverge taper

For the left turn merge to the major road, the cleavage will be provided by a direct taper to a width of 3.5m at the corner into the minor road (preferably of radius at least 25m minimum). The width shall be determined from Table 7/2. The detail of the island as approached along the minor road is as set out in Annex 2. The width of the lane will depend on the radius of the diverge taper determined from Table 7/2, which should be decreased as a constant taper depending on the design speed (Figs 7/13).

#### A) Lane width around diverge channelising island shall be as given in Table 7/2

**In principle**

None

| TD 42 | 7.54 | Diverge taper | Radial | Lane width around diverge channelising island shall be as given in Table 7/2 | None | NA | NA | NA | 1) For MDD comments refer to TD 41/42 scoping study. | NA |

#### B) Width of turning lane as set out in TD 42 for various radii

**In principle**

None

| TD 42 | 7.54 | Diverge taper | Radial | Width of turning lane as set out in TD 42 for various radii | None | NA | NA | NA | 1) For MDD comments refer to TD 41/42 scoping study. | NA |

### TD 42 7.61 Merge taper

For the left turn diverge from the major road, the cleavage will be as shown in Figs 7/18 and 7/19 shall be designed so as to provide a constant width around the turn to the minor road. The width shall be determined from Table 7/2. The detail of the island as approached along the minor road is as set out in Annex 2. The width of the lane will depend on the radius of the merge taper determined from Table 7/2, which should be decreased as a constant taper depending on the design speed (Figs 7/13).

#### A) Lane width around merge channelising island shall be as given in Table 7/2

**In principle**

None

| TD 42 | 7.61 | Merge taper | Radial | Lane width around merge channelising island shall be as given in Table 7/2 | None | NA | NA | NA | 1) For MDD comments refer to TD 41/42 scoping study. | NA |

#### B) Width of turning lane as set out in TD 42 for various radii

**In principle**

None

| TD 42 | 7.61 | Merge taper | Radial | Width of turning lane as set out in TD 42 for various radii | None | NA | NA | NA | 1) For MDD comments refer to TD 41/42 scoping study. | NA |

### TD 41 2.32 Diverge Tapers

For the left turn diverge from the major road, the cleavage shall be formed by a direct taper to a width of 3.5m at the corner into the direct access (preferably of radius 25m). The width of this corner will depend on the radius selected. These figures are given in TD 42 (DMR 6.2.6). Left turning traffic shall be given way to traffic turning right from the major road. The diverge taper length is given on Layout 9.

#### A) Radius at end of taper to be 'preferably of radius 25m'.

**In principle**

None

| TD 41 | 2.32 | Diverge Tapers | Layout 9 | Radius at end of taper to be 'preferably of radius 25m'. | None | 7.54 | NA | 1) For MDD comments refer to TD 41/42 scoping study. | NA |

#### B) Width of turning lane as set out in TD 42 for various radii

**In principle**

Yes

| TD 41 | 2.32 | Diverge Tapers | Layout 9 | Width of turning lane as set out in TD 42 for various radii | Yes | 7.54 | NA | 1) For MDD comments refer to TD 41/42 scoping study. | NA |

### TD 41 2.35 Merge Tapers

For the left in left out junctions are also dealt with in TD 40. The parameters are the same across both documents with the exception that the radius at the start of the merge/diverge shall be increased from 25m to 30m (merges) and from 20m to 30m (diverges) above 85kph design speed in TD 42. Nonetheless, the plant proposal of the TD 42 and TD 40 scoping studies is that only the replacement TD 42 RAD will deal with left in left out junctions in the future. Any conflict will be eliminated.

#### A) The parameters are the same across both documents with the exception that the radius at the start of the merge/diverge shall be increased from 25m to 30m (merges) and from 20m to 30m (diverges) above 85kph design speed in TD 42.

**In principle**

Yes

| TD 41 | 2.35 | Merge Tapers | Layout 10 | The parameters are the same across both documents with the exception that the radius at the start of the merge/diverge shall be increased from 25m to 30m (merges) and from 20m to 30m (diverges) above 85kph design speed in TD 42. | Yes | 7.54 | NA | 1) For MDD comments refer to TD 41/42 scoping study. | NA |

#### B) The plant proposal of the TD 42 and TD 40 scoping studies is that only the replacement TD 42 RAD will deal with left in left out junctions in the future.

**In principle**

Yes

| TD 41 | 2.35 | Merge Tapers | Layout 10 | The plant proposal of the TD 42 and TD 40 scoping studies is that only the replacement TD 42 RAD will deal with left in left out junctions in the future. | Yes | 7.54 | NA | 1) For MDD comments refer to TD 41/42 scoping study. | NA |
i) The last sentence of the final paragraph is almost identical to TD 42 Clause 7.18, except in TD 42 the use of a... as per TD 41. Notwithstanding this, recommendations made as part of the TD 41/42 scoping study will resolve this issue.

ii) This remainder of the Clause duplicates TD 41 Clause 7.17; however, recommendations made as part of the TD 41/42 scoping study will resolve this issue.

A) Recommended min radius at simple junctions is 6m for urban and 10m for rural where no provision is made for HGVs.

B) Where provision is made for HGV refer to clause bullets.

C) Where the trunk road has a 1m strip and LGOs comprise a significant proportion of the turning movements then the compound curve shown in TD 42 (DMRB 6.2.6) shall be used.

In principle

TD 42 Clause 7.17

1) Terms such as ‘desirable minimum’ and ‘absolute minimum’ are ambiguous. The table uses too many terms which makes it convoluted.

2) The table layout/format is not entirely clear, particularly as to how the relaxation process works.
<table>
<thead>
<tr>
<th>Doc</th>
<th>Clause</th>
<th>Subject</th>
<th>Parameter</th>
<th>Clause Text</th>
<th>Extracted Requirement/Advice</th>
<th>Duplication/Conflict</th>
<th>MDD Comments</th>
<th>General Comments</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>TD 9</td>
<td>3.1</td>
<td>Camber</td>
<td>Crossfall</td>
<td>On sections of road with radii greater than that shown in Table 3, (minimum R with superelevation of 5%), (i.e. V²/R &gt; 7) adverse camber &amp; transitions, (i.e. V²/R &lt; 5) the superelevation shall be provided, such that: crossfall or camber should be 2.5% from the centre of anle carriageways, or from the central reserve of dual carriageways to the outer channels. At junctions other than roundabouts, the cross-section of the major road shall be retained across the junction, and the side road graded into the channel line of the major road. On horizontal curves, adverse camber shall be replaced by favourable crossfall of 2.5% when the radius is less than that shown in Table 3, (minimum R without elimination of adverse camber &amp; transitions), (i.e. V²/R &lt; 5). However, it will frequently be necessary to eliminate adverse camber on larger radii for aesthetic or drainage reasons.</td>
<td>A) Crossfall &amp; camber to be 2.5% if above radii without elimination of adverse camber.</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>TD 9</td>
<td>3.2</td>
<td>Camber</td>
<td>Superelevation</td>
<td>On radii less than those shown in Table 3, (minimum R with superelevation of 5%), (i.e. V²/R &gt; 7) superelevation shall be provided, such that: $S = V^2 / 2.828 \times R$ Where $V$ = Design Speed kph $R$ = Radius of Curve m. $S$ = Superelevation %. In urban areas superelevation shall not exceed 5%</td>
<td>A) Formula for superelevation where radius is less than min. R with 5% super elevation. B) 7% max superelevation in rural areas. C) 5% max superelevation in urban areas with at-grade junctions/access.</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>TD 9</td>
<td>3.3</td>
<td>Geometry</td>
<td>Radii</td>
<td>The Desirable Minimum radii, corresponding with superelevation of 5% and radii below Desirable Minimum with superelevation of 7% are shown in Table 3 (i.e. V²/R 0.5% &gt; 14 Desirable, 20 Absolute Maximum).</td>
<td>A) Desirable min radius given in Table 3</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>TD 9</td>
<td>3.8</td>
<td>Geometry</td>
<td>Curve widening</td>
<td>For Carriageways of Standard Width, (7.3m, 11m, and 14.6m for 2, 3 or 4 lanes respectively), an increase of 0.3m per lane shall be allowed when the radius is between 90m and 150m. Two lane roads of width greater than 7.3m require no additional widening.</td>
<td>A) For carriageways of standard width, 0.3m per lane ‘shall be allowed’ when the radius is between 90 and 150m. B) Two lane roads wider than 7.3m require no additional widening.</td>
<td>None</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>TD 9</td>
<td>3.11</td>
<td>Geometry</td>
<td>Curve widening</td>
<td>For Carriageways less than the Standard Widths, widening shall be: 0.6m per lane where the radius is between 90m and 150m subject to maximum carriageway widths of 7.3m; 11.9m and 15.8m (for 2, 3 and 4 lanes respectively). 0.5m per lane where the radius is between 150m and 300m subject to a maximum width not greater than the standard width in Paragraph 3.8 above. 0.3m per lane, where the radius is between 300m and 400m subject to a maximum width not greater than the standard width in Paragraph 3.8 above.</td>
<td>A) For carriageways less than the standard widths, widening shall be: (i) 0.6m per lane for R of 90m to 150m subject to max. c'way width of 7.3m, 11.9m and 15.8m. (ii) 0.5m per lane for R of 150m to 300m; subject to max. c'way width not greater than standard (para 3.10). (iii) 0.3m per lane for R of 300m to 400m; subject to max c’way width not greater than standard (para 3.10).</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>TD 9</td>
<td>3.12</td>
<td>Geometry</td>
<td>Radii</td>
<td>Radii less than 90m on the mainline are Departures from standard. For these and all other junction elements, widening should be in accordance with TA 20 (DMRB 6.2).</td>
<td>A) Less than 90m radii on the mainline is a departure. B) Widening at junctions should be in accordance with TA 20.</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>TD 9</td>
<td>3.13</td>
<td>Geometry</td>
<td>Curve widening</td>
<td>The extra width should be applied uniformly along the transition curves. In the improvement of existing curves the widening should generally be made on the inside of curves.</td>
<td>As clause text</td>
<td>None</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>Doc</td>
<td>Clause</td>
<td>Subject</td>
<td>Parameter</td>
<td>Clause Text</td>
<td>Extracted Requirement/Advice</td>
<td>MDD Comments</td>
<td>General Comments</td>
<td>Notes</td>
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</table>
| TD 9 | 3.14 | Geometry | pinch points lane widths | At points of particular difficulty on new dual carriageways, where full lane widths cannot be achieved, a reduction from 3.65m to 3.50m is permitted provided that the radius of curvature exceeds 1000m. Points where such a relaxation are likely to be most applicable are around the urban fringes, and at sites with difficult topography or in historic or conservation areas. This relaxation shall not apply on new single carriageway roads. | None | NA | NA | NA | 1) points of particular difficulty is ambiguous.  
2) The second sentence provides no useful requirements of advice.  
3) The last sentence superfluous as the first sentence clearly refers to 'new dual carriageways'. |

| TD 9 | 3.15 | Geometry | Geometry Transition curves | Transition curves shall be provided on curves the radius of which are less than that shown in Table 3, Minimum R without elimination of adverse center & transitions. | None | NA | NA | NA | This clause is of little useful without a link to the related requirements. |

| TD 9 | 3.16 | Geometry | Geometry Transition curves | The basic transition length shall be derived from the formula: \( L = \frac{V^3}{46.7 \cdot q \cdot R} \)  
Where: \( L \) = Length of transition (m) \( V \) = Design Speed (kph) \( q \) = Rate of increase of centripetal acceleration (m/sec³) travelling along curve at constant speed \( V \) (kph) \( R \) = Radius of curve (m)  
\( q \) should normally not exceed 0.3 m/sec³, although in difficult cases, it may be necessary to increase the value up to 0.6 m/sec³. On bends (sub-Standard curves for the appropriate Design Speed) the length of transition should normally be limited to the square root of 24R metres. | Formula for length of transition curves | None | NA | NA | NA | 1) in the last paragraph 'should normally' and 'difficult cases' is ambiguous.  
2) The second sentence provides no useful requirements of advice.  
3) The last sentence superfluous as the first sentence clearly refers to 'new dual carriageways'. |
Appendix B. TD 22, TD 42 and TSM Tapers