City of Wodonga

Design Guidelines for Building on Sloping Land

6 December 2019
Contents

Introduction ................................................................................................................................................. 3
Where do the Guidelines apply? .................................................................................................................. 3
Slope Management Plan ............................................................................................................................. 3
What should a slope management plan include? ....................................................................................... 3
Design Guidelines ........................................................................................................................................ 4
Objectives ................................................................................................................................................... 4
Gradient of Slope Calculation Table ......................................................................................................... 8
Appendix ..................................................................................................................................................... 9
Testing of Housing Typologies .................................................................................................................. 9
Cost analysis of alternative construction approaches ............................................................................. 15
Introduction
The City of Wodonga sits in attractive undulating topography at the foothills of the Great Dividing Range. Most of the city has been built to date on the gentle slopes along the Murray River valley. However, as it continues to grow it is expected to move into the foothills and increasingly have to address the impacts of sloping land on streets, houses and public spaces.

It is estimated that more than 25 per cent of future residential land is subject to significant slope of more than 18% (10 degrees) across several development fronts. A significant cost component when building on sloping land includes those for earthworks and engineered retaining walls. Choosing the right house design for a sloping site can assist in keeping these costs to a minimum.

To better address building on sloping land, these guidelines have been prepared to assist land and housing providers to deliver more site responsive streets and houses, and for council in reviewing and assessing applications for these.

Where do the Guidelines apply?
The guidelines apply to planning applications for subdivision and development of land in the growth areas of the City of Wodonga that is zoned for residential use and with a minimum average pre-development slope of 10% (1 in 10). Subdivision that will result in buildings and works on any areas of land with an average slope over 20% will not be supported because of potential construction, servicing, storm water and erosion impacts.

Slope Management Plan
The guidelines recommend preparation of a Slope Management Plan when applying for a planning permit to subdivide and develop land on slopes of 10% or more. The Slope Management Plan should demonstrate that the proposed development will positively respond to the topography of the land.

The plan should demonstrate how the following considerations have been adequately addressed:

- Minimisation of major cut and fill earthworks for streets and house sites
- Use of retaining walls is appropriate to the setting and that their distribution is minimised, and height is less than 900mm in any single rise
- The collection and distribution of storm water is properly managed to minimise erosion and impacts on neighbouring properties or land or waterways

What should a slope management plan include?
A Slope Management Plan submitted with a planning permit application for subdivision should include:

- A site description and design response. The site description must include a plan of predevelopment slope (contours) and categorise the slope into areas of less than 10%, 10-15%, 15-20% and greater than 20% (as applicable). The design response for the proposed subdivision must explain how the design derives from and responds to the slope, proposed neighbourhood character and site description.
- A statement describing how any land with a pre-development slope over 10% will be subdivided and/or developed to complement adjacent land.
- A design response detailing how areas of slope over 20% will be mitigated through the implementation of the Slope Management Plan.
• A statement and/or diagrams detailing the proposed landscape and urban design outcomes that will be achieved to complement the slope and mitigate any impacts of retaining walls and batters.
• A geotechnical report and designs by a suitably qualified engineer to confirm the stability of the natural slope and man-made soil deposits and assess risks posed by the site conditions and proposed earthworks and drainage, eg, to confirm soil type will support benching of the site and drainage relating to cut.
• Proposed road cross sections and long sections to demonstrate how slopes over 10% are being addressed through the design.
• Details of all proposed batters, cut and fill earthworks, retaining walls, driveway and crossover locations and drainage solutions required for the subdivision of land that includes existing pre-development slope of greater than 10%.
• Details of any proposed retaining walls, including overall height, staggering of retaining walls, finished levels, construction materials and associated fencing required.
• Building envelopes (or an alternative design response) to respond to the slope management methods utilised.
• Details of how erosion and sediment will be managed during construction of both subdivision and buildings in accordance with current environmental management best practice, to prevent sediment-laden water from entering any drainage system or natural waterway.

Design Guidelines
The following guidelines are provided to assist in the preparation of a Slope Management Plan. They include objectives that must be achieved, design guidelines which should assist in achieving the objective and design tips offering possible design solutions.

Objectives
To ensure that the layout of new developments positively responds to the undulating topography

Guidelines
Align streets generally with the contours on land with slopes averaging greater than 10% or 1:10. Layout street blocks and lots with greater depth to allow enough space to accommodate house and associated landscape treatments. Where this is not practical, align streets perpendicular to the slope and layout lots with wider frontages allowing enough space for likely site crossfall.

Tip
On slopes greater than 10% provide minimum lot sizes of 1000m2 with a minimum frontage of 25m.

Where streets are aligned with the contours the preferred maximum crossfall is 10%. In areas where grades exceed 10% the use of split-level streets may provide an alternative design solution.

Where streets are aligned perpendicular to the contours the preferred maximum longitudinal grade is 10%.
To minimize disturbance to the natural topography through excessive earthworks and associated retaining structures

Guidelines

Layout lot dimensions and proportions responding to the topography of the area and the alignment of streets

Retain mature vegetation where practical to assist with slope stability

Tip

On streets running perpendicular to the contours, layout lots with wider frontages to provide larger setbacks and allow space for cut and fill and any associated retaining walls, batters or embankments. This should also allow space for establishment of effective landscape treatments within allotments.

Fig 1. Streets perpendicular to contours - wide frontages

Fig 2. Streets perpendicular to contours - narrow frontages

On streets running parallel to the contours layout the lots to provide enough space for houses to align with the contours or to step down the slope

Fig 3. Streets parallel to contours. Larger blocks with wider frontages
To minimize cut and fill on sloping sites through site responsive house designs

**Guideline**

Apply house designs using stepped floor levels to take up the site slope within the building.

Layout and locate private open space to respond to the slope and relationship to building functions

**Tip**

Single slab-on-ground construction, as in most “off the shelf” designs, are only appropriate for flat to slightly sloping sites less than 10% gradient.

For moderate slopes between 10 and 15 per cent use two or more slabs or part slab/part post and beam construction to address the slope.

---

**Fig 4.** Slope 10%, 1:10 or 5.7°

**Fig 5.** Slope: 15%, 1:6.6 or 8.6°
Steep slopes around 20% are particularly challenging to build upon. For these or greater slopes consider post and beam construction which steps with the site and requires less excavation for footings.

Fig 6. Slope: 20%, 1:5 or 11.3°

Fig 7. Steeply sloping site greater than 20%

**Tip**

Limit cut and fill and retaining wall heights to a maximum of 900mm. If higher walls are necessary, step these in rises of not more than 600mm with a minimum spacing of 900mm to allow for landscaping.

**Tip**

Locate garages and establish their floor levels to provide less steep driveways. Ensure driveways have gradients of less than 20%.

Fig 8. Garage locations
To avoid impacts from storm water run-off on neighbouring properties, streets and public spaces

**Guideline**

Prepare a Site Environmental Management Plan (SEMP) to identify the potential erosion, sediment or other environmental risks that may occur during construction and the mitigation measures required to address these risks.

**Tip**

Relevant sections from the *Environmental Protection Authority-Melbourne Water Site Environmental Management Plan-Guidance Notes and charts* provide a useful template for preparation of a SEMP.

**To maximize opportunities for landscaping**

**Guidelines**

Layout lots to provide enough space for establishing effective landscaping including trees with spreading canopies.

Provide street trees with spreading canopies to moderate the visual impacts of built form.

**Gradient of Slope Calculation Table**

<table>
<thead>
<tr>
<th>Gradient of Slope (%)</th>
<th>Gradient of Slope (Ratio)</th>
<th>Gradient of Slope (Degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td>1:20</td>
<td>2.8°</td>
</tr>
<tr>
<td>10%</td>
<td>1:10</td>
<td>5.7°</td>
</tr>
<tr>
<td>15%</td>
<td>1:6.6</td>
<td>8.6°</td>
</tr>
<tr>
<td>20%</td>
<td>1:5</td>
<td>11.31°</td>
</tr>
<tr>
<td>25%</td>
<td>1:4</td>
<td>14°</td>
</tr>
<tr>
<td>30%</td>
<td>1:3.3</td>
<td>16.9°</td>
</tr>
</tbody>
</table>
Appendix.

Testing of Housing Typologies

This section provides analysis of two typical house designs applied to sloping sites with different gradients, access arrangements and orientation. This is followed by cost analysis of the designs located on three different slopes. The objective has been to understand what, if any, the implications these variables would have for the functionality, construction method, energy performance and cost of the houses.

The designs are based on a typical standard construction house from a volume builder of 4 Bedrooms, 2-3 Bathroom with 2 car garages. The designs have been slightly adapted to align along the contours, and accordingly, to be able to accommodate changes in floor level in logical locations within the floorplan.

A typical block size of +/- 600m² has been assumed with the wider dimension along the frontage to better enable layout of the building floorplan along the contours to reduce the amount of excavation or engineered retaining walls. Whilst the block size is smaller than advised by local industry sources for sloping sites it has been chosen to test whether it is feasible to build a typical volume house on sloping land with limited cut and fill and retaining walls.

The floor plan has been applied and adapted to three different slope gradients of 10, 15 and 20%, or 1:10, 1:6.6 or 1:5.

Floor plans have also been analysed with access from up slope and down slope configurations to assess how this affects layout particularly regarding living room locations and to limit driveway gradients as much as possible.

Assessment of solar orientation indicates that access to sunlight is not substantially affected for the houses except for those on a due south facing 20% slope. This condition can be addressed through alteration of the roof design to include north facing clerestory windows to allow sun penetration to living areas (refer Section B-B at 20% slope).

The analysis demonstrates that it should be feasible to apply a standard design house, with some modifications to floor levels, to a range of different slope conditions, access arrangements and orientation whilst avoiding excessive amounts of bulk earthworks and associated tall engineered retaining walls.
HOUSE ONE - Plan based loosely on Metricon Berkshire 34 plan
Scale 1:100 @ A3
Date: 24 September 2019
SECTION B-B

Scale 1:100 @ A3
Date: 1.10.19

Split Roof for South-Facing Houses

1800mm
20%

1500mm
15%

800mm
10%
Orientation Study

Numbers on plan indicate either House 1 or 2. Arrows denote access

Note: this study is equally applicable to West-facing slopes and South-facing slopes with the exception of roof forms which need modification to allow solar access to living rooms. (See Cross-section B-B)
Cost analysis of alternative construction approaches

The probable cost of the two house designs has been analysed by PlanCost Quantity Surveyors over three average gradients of 10, 15 and 20% or 1:10, 1:6.6 and 1:5. A base line figure for slab-on-ground construction on a flat site is provided against a comparison of three construction methods:

- Full bench with full slab-on-ground
- Partial bench and partial suspended concrete floor
- Partial bench and partial suspended timber floor on stumps

Only the costs presumed to be affected by the sloping site are included in the analysis. The items costed include:

- Design contingencies
- GST
- Floor structure
- Subfloor structure
- Footings
- Steps/Stairs
- Balustrades
- Bulk excavation and fill
- Retaining walls

All other items such as fees and charges, walls, roofs, internals, site works, escalation, etc are excluded as these are deemed not to be affected by the sloping site.

Predictably, the analysis shows that construction costs for both house types increase in proportion to the increase in slope. For House type 1 on the lower grade of 10% a fully benched site with slab on ground is the least expensive approach. At 15% this approach is matched by a partial bench and partial suspended timber floor and at 20% the full bench and slab on ground becomes less expensive than partial bench with partial suspended concrete floor and full bench with slab on ground.

For the slightly smaller House type 2 at 10% slope, the full bench with slab on ground is slightly less expensive than partial bench and suspended timber floor, which is then the least expensive approach at the steeper slopes of 15% and 20%. The differentials in anticipated costs for the alternative methods for both house types indicate that there is not a significant penalty for the options requiring less earthworks, retaining walls and landform impacts. In fact, for the steeper slopes, the figures indicate a potential cost saving of about 5% for a house costing $350,000 against the business as usual approach of full bench with slab on ground. This demonstrates that this approach can provide improved built and landscape outcomes for development on sloping land.
<table>
<thead>
<tr>
<th>Cost Component</th>
<th>GFA</th>
<th>Substructure &amp; Steps</th>
<th>Excavation, Fill &amp; Retaining</th>
<th>5% Design Constingency</th>
<th>GST 10%</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>House 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0% slope- Full Slab on Ground</td>
<td>316m²</td>
<td>54,000</td>
<td>0</td>
<td>3,000</td>
<td>6,000</td>
<td>63,000</td>
</tr>
<tr>
<td>10% slope- Partial Bench and Partial suspended Floor (concrete)</td>
<td>316m²</td>
<td>92,000</td>
<td>11,000</td>
<td>6,000</td>
<td>11,000</td>
<td>120,000</td>
</tr>
<tr>
<td>10% slope- Partial Bench and Partial suspended Floor (timber)</td>
<td>316m²</td>
<td>84,000</td>
<td>11,000</td>
<td>6,000</td>
<td>11,000</td>
<td>112,000</td>
</tr>
<tr>
<td>10% slope- Full Bench and Full Slab on Ground</td>
<td>316m²</td>
<td>71,000</td>
<td>18,000</td>
<td>5,000</td>
<td>10,000</td>
<td>104,000</td>
</tr>
<tr>
<td>15% slope- Partial Bench and Partial suspended Floor (concrete)</td>
<td>316m²</td>
<td>92,000</td>
<td>21,000</td>
<td>6,000</td>
<td>12,000</td>
<td>131,000</td>
</tr>
<tr>
<td>15% slope- Partial Bench and Partial suspended Floor (timber)</td>
<td>316m²</td>
<td>84,000</td>
<td>21,000</td>
<td>6,000</td>
<td>12,000</td>
<td>123,000</td>
</tr>
<tr>
<td>15% slope- Full Bench and Full Slab on Ground</td>
<td>316m²</td>
<td>72,000</td>
<td>33,000</td>
<td>6,000</td>
<td>12,000</td>
<td>123,000</td>
</tr>
<tr>
<td>20% slope- Partial Bench and Partial suspended Floor (concrete)</td>
<td>316m²</td>
<td>108,000</td>
<td>20,000</td>
<td>7,000</td>
<td>14,000</td>
<td>149,000</td>
</tr>
<tr>
<td>20% slope- Partial Bench and Partial suspended Floor (timber)</td>
<td>316m²</td>
<td>97,000</td>
<td>20,000</td>
<td>7,000</td>
<td>14,000</td>
<td>138,000</td>
</tr>
<tr>
<td>20% slope- Full Bench and Full Slab on Ground</td>
<td>316m²</td>
<td>77,000</td>
<td>35,000</td>
<td>6,000</td>
<td>12,000</td>
<td>130,000</td>
</tr>
<tr>
<td><strong>House 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0% slope- Full Slab on Ground</td>
<td>293m²</td>
<td>50,000</td>
<td>0</td>
<td>3,000</td>
<td>6,000</td>
<td>59,000</td>
</tr>
<tr>
<td>10% slope- Partial Bench and Partial suspended Floor (concrete)</td>
<td>293m²</td>
<td>83,000</td>
<td>11,000</td>
<td>5,000</td>
<td>10,000</td>
<td>109,000</td>
</tr>
<tr>
<td>10% slope- Partial Bench and Partial suspended Floor (timber)</td>
<td>293m²</td>
<td>78,000</td>
<td>11,000</td>
<td>5,000</td>
<td>10,000</td>
<td>104,000</td>
</tr>
<tr>
<td>10% slope- Full Bench and Full Slab on Ground</td>
<td>293m²</td>
<td>67,000</td>
<td>17,000</td>
<td>5,000</td>
<td>10,000</td>
<td>98,000</td>
</tr>
<tr>
<td>15% slope- Partial Bench and Partial suspended Floor (concrete)</td>
<td>293m²</td>
<td>90,000</td>
<td>14,000</td>
<td>6,000</td>
<td>11,000</td>
<td>121,000</td>
</tr>
<tr>
<td>15% slope- Partial Bench and Partial suspended Floor (timber)</td>
<td>293m²</td>
<td>86,000</td>
<td>14,000</td>
<td>6,000</td>
<td>11,000</td>
<td>107,000</td>
</tr>
<tr>
<td>15% slope- Full Bench and Full Slab on Ground</td>
<td>293m²</td>
<td>71,000</td>
<td>33,000</td>
<td>6,000</td>
<td>11,000</td>
<td>121,000</td>
</tr>
<tr>
<td>20% slope- Partial Bench and Partial suspended Floor (concrete)</td>
<td>293m²</td>
<td>106,000</td>
<td>14,000</td>
<td>6,000</td>
<td>13,000</td>
<td>139,000</td>
</tr>
<tr>
<td>20% slope- Partial Bench and Partial suspended Floor (timber)</td>
<td>293m²</td>
<td>84,000</td>
<td>14,000</td>
<td>6,000</td>
<td>13,000</td>
<td>117,000</td>
</tr>
<tr>
<td>20% slope- Full Bench and Full Slab on Ground</td>
<td>293m²</td>
<td>74,000</td>
<td>35,000</td>
<td>6,000</td>
<td>12,000</td>
<td>127,000</td>
</tr>
</tbody>
</table>