Adelaide Hills Rail

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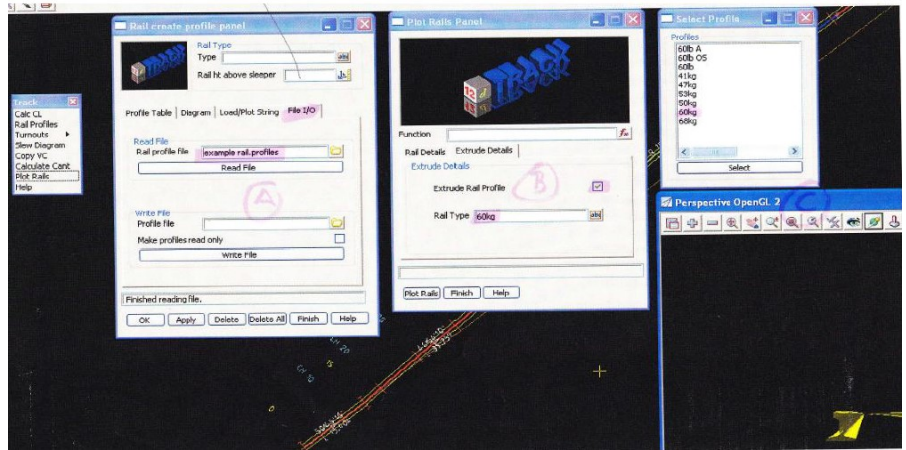
SCOPE:

Ballast depth under rail

12d DIMENSIONS:

- Rail

Project Summary

The addition of 12d Track (for rail) to 12d Model software has helped many designers produce better results, especially when customisations are applied. The use of 12d Model with 12d Track on the Adelaide Hills Rail project saved time and money, and assisted design processes greatly.

For more information

To find out more about how you can create better designs faster with the 12d Model solution for civil engineering design, visit www.12d.com.

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The Challenge

It was necessary on this project to have plotted cross sections showing rail design formation with the track infrastructure correctly displayed. This meant having the ballast, sleepers and rail profiles shown in all cross sections, but on the correct cant at the horizontal curves.

It was also important to be able to calculate the exact ballast depths under the sleepers at both (high and low) rail locations. This value was critical as all the loads of the train were directly bearing under the rail foot, and the minimum designed depth needed to be maintained. Axle loads in the Pilbara in Western Australia on heavy haul rail are reaching up to 40-tonne limits.

The Solution

After creating the super alignment consisting of horizontal and vertical geometry, the Cant Panel macro (and then the Plot Rails macro) were applied.

There were 4 important inputs required in the Cant Design Tab:

1. Alignment speed (from design criteria)
2. Track Gauge (from design criteria)
3. Kec
4. Ksc

(Both Kec and Ksc are constants, where item 4 in reality is variable in rail designing.)

The designer then produced a 'speed table' which calculated the cant (superelevation) required to accommodate the speed and radii of design curves. The mathematical formulae of these can vary slightly depending on the rail size and gauge between inside rail faces.

The Kec constant is derived from the formula Kec = S/g * (3.6)² where S is the centreline spacing of the rails, g is gravitational acceleration (taken as 9.8m/²) and 3.6 is the conversion factor to allow the use of V (km/h) instead of Vm (m/s).

An example of heavy haul rail was using 68kg rail with 75mm width of rail head on a standard gauge being 1435mm → 1435 + (2 * 37.5mm) / 9.8 * 3.6² which = 11.89 Kec value.

This 11.89 value was used in calculating the applied equilibrium cant allowed.

The formula used for that was Ee=11.89*V²/R where V is speed and R is horizontal radius.

The item 4 value, although being a constant, did vary pending each curve on the design. The value was brought about by the curve requiring some deficiency in the calculated equilibrium cant. The idea of cant deficiency being a lower cant than calculated is to 'drive' the train with gravitational force into the rails, thereby having a smoother continuous ride than any slack between the wheels and the rails where the ideal equilibrium was originally calculated. This value is generally two thirds (~66%) of the chosen applied cant Ea to the equilibrium cant.

Therefore, after all that to calculate item 4, simply 66% of Kec Value, an example being 11.89 *0 .66 = 7.847 Ksec.

The next step in the design process was to run the Plot Rails macro. This macro produces 12d models for rail strings, ballast string & sections and sleepers.

This example had a sleeper depth of 200mm, minimum ballast depth under sleeper of 200mm and rail with seating pad of 235mm. This equated to 635mm above the designed rail formation. The height offset was 0.635. The other dimension Rail to Ballast height was 0.235 (correct as the ballast came to the top of the

12d° Model

sleeper level when there was no sleeper present, as sleepers spaced generally 600mm centre to centre). Also worth explaining is the width, which is the ballast shoulder edge to shoulder, in this case 150mm is used for the shoulder and sleeper width is 2520mm, therefore 2.82.

The simple choice of selecting the correct Rail Type, (base of rails tab) was applied only after the using the Rail Profiles macro.

This allowed importing previously profiled rails into the project. The 'examplerail.profile' file supplied with 12d Model was copied into the project, then the File I/O was used.

This was extruded and displayed in a Perspective OpenGL view, but still was only a point in a typical cross section indicating top of rail - there was no rail profile. The designer wanted to take things a bit further with some innovative ideas.

The first objective was to establish what 12d Model could already produce, and then see if it could be enhanced further. Using the Plot Rails panel produced the rail model strings at gauge centres (face to face), and the correct cant.

The ballast required that a 'ballast.tin' be created from the models with the default 'nulling' values; this enabled the

had to be renamed to identify the left and right rails. Increasing chainage direction to determine left and right was used. This was important when using the plot routine.

Once the designer had all the tools to start populating the cross section plot PPF editor, since a left and right rail profile appearing with the correct symbol was desirable, it was necessary to ensure a separate name within the rail string model for left and right. The reason was that when 'Cuts' are used in the plot routine a defined set of numbers is allocated and newly created rail symbols can be positioned on the associated defined sets.

After running the plot routine, a cross section was developed and accomplished, having plotted cross sections showing rail design formation with the track infrastructure correctly displayed.

The final output was exactly as desired, and further benefits flowed through. The quantity of the ballast became easier to calculate by applying a ballast TIN to formation TIN volume report and simply deducting sleeper cross sectional areas. Another great advantage was that 12d Model's Visualisation could be used to create different rendering and realistic drive through movie (*.avi) files.

The task of establishing the exact ballast depth below the rail foot was a matter of applying some innovation to the data that had been created. It was necessary to first

LDP005 & VL360 on SCT Freight Adelaide Hills Rail Movements

TIN to be viewed and cut, giving the ballast shape at any point along the alignment.

The next items were the sleepers - this simply required a 'corridor overlap' in the cross section plot routine to include the sleepers. This overlap was half the sleeper spacing, with sleepers designed at 600mm centres then 300mm.

The rail required a symbol to be drawn that could be called up in the cross section plot routine. Yet, it was necessary to draw two symbols as the insertion point was on the face of the rail because 12d Model produced strings at rail gauge centres; standard gauge being 1435mm (broad – 1600mm; narrow -1000mm).

The origin of the symbol was critical to the correct placement on the rail model string. The rail model strings

understand why this can vary, and how to rectify the issue if the minimum depth specified is encroached.

The area where this was likely was in horizontal curves only - this is where the cant or superelevation occurs and which puts the sleepers and rail on a one way cross fall. The designed formation below is generally crowned but can also have one way cross fall, normally for use in rail duplication projects which require drainage run off. This formation cross fall grade is about 2% either crowned or one way. Problematically, if the cant designed for that particular horizontal bend is greater than the formation grade of 2%, then these two grades would eventually cross one another as the cant being steeper than the formation. The low rail is where the ballast depth encroachment will occur.

Once this information was gathered, the designer could

Approaching the Eden Hills tunnels

start working with the 12d Model rail left and right strings created earlier by the Plot Rails macro. The track criteria example:

- 47 kg/m Rail inclusive of rail seat – 141mm

- Sleeper depth under rail seat – 200mm

- Ballast under sleeper at rail seat – 200mm

- Fall of formation by ½ rail gauge – 717.5mm * 2% = 14mm

As mentioned, the ballast depth can be an issue when there is one-way cross fall on the design formation and not a typically crowned formation. Some engineers will debate that having a reduced ballast at the centre of the track is not an issue considering the loads are somewhat reduced compared to directly over the rail. This means a reduced value in this example by 14mm, therefore 186mm ballast. This does contradict the design specification which dictates a minimum of 200mm ballast under the sleeper, but the criteria generally do not indicate where along the sleeper. So adding the 14mm ensures the minimum is maintained at the crown work point under the sleeper and an additional 14mm (in this case) under the rail.

The combined dimensions total 555mm - this is the input value in the Height Offset panel described earlier. The next step was the 12d function of draping onto a TIN. The created models of the left and right rail strings (yellow points above sleeper) were draped onto the design formation. This created the draped strings on the design formation. The next step was to create a QA Report within the 12d environment. Here the 'Check As Built Design String vs Design String' at 10m intervals was used (the Xfall/Offset report can also achieve results).

- As Built String = draped string

- Design String = Top of rail string (above sleeper)

- Control String = Alignment CL (shown at crown of red formation)

The results of such reporting can be exported into Excel software and, using 'if' statements, the designer can colour highlight 'cells' indicating less than 555mm. This final report can be a great resource for design considerations between the designer, engineer and the client.

These results can show some areas where ballast is less than desired. One must consider the depth change and over how many meters of the alignment where this reduction is occurring and may not warrant any work to the existing design. Yet, if there are significant distances where the ballast is far less than desired then the designer can increase the rail height locally in these areas of concern. This is a difficult task. Heavy haul rail design has specific

criteria for vertical intersection points (VIPs) which is commonly a distance of 1000m between VIPs. This can cause higher ballast volumes than necessary due to some local earthworks dipping which dictates the low point between VIPs. The cant can also be looked at by reducing the value thereby reducing the height variation between high and low rails, which in turn would increase the depth between the draped string on the formation and the new low rail position.

The other alternative is to steepen the formation locally by introducing a new VIP and maintain the rail 1km VIPs as this is the primary running surface of the train but the earthworks below can vary to accommodate design constraints. Best adopt a super alignment for rail and another for the design formation. This is common as the longitudinal plotted profile needs to show both alignments. The combination of the existing rail macros and 12d functions such as drape, followed by creating a report, validates the ballast depth which ensures the client the design criteria is validated and more importantly meant being able to calculate the exact ballast depths under the sleepers at both (high and low) rail locations.

Mount Lofty Station

Result

Despite the many difficulties involved in such a complex project, the use of 12d Model with 12d Track on the Adelaide Hills Rail saved time and money, and assisted design processes greatly.

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12d Track has been specifically designed for the survey, design and construction of light, heavy and high speed rail projects.

Extensive railway tools in 12d Track allow the rail designer to quickly and easily design their projects. These options are built on the existing 3D modelling and design tools available in 12d Model.

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Powerful clash detection management allows for efficient 3D modelling of service networks such as gas, electricity, telecommunications and water prior to construction.

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12d Model is a complete surveying package providing the tools to manage all facets of surveyed data including LIDAR, topographical, as-built, conformance, traversing, geodetics, data mapping, labelling and much more.

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12d Model assists with the design, construction and mapping of oil and gas pipelines, original site exploration and the wide range of infrastructure required for oil and gas projects.

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12d Model is the ultimate software for construction with powerful set-out options, direct interfaces to machine control and detailed conformance reporting and auditing.

Manage 3D data and control volumes, quantities and progress claims with 12d Model. Set-out your project and undertake conformance and as-built surveys live on-site using 12d Field.
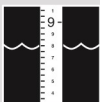
Rivers, Dams and Hydrology

12d Model handles very large datasets and interfaces with a wide range of analysis packages, making it perfect for flood studies and the management of rivers and dams.

12d has partnered with industry leading analysis software, allowing users to apply 2D drainage analysis from within 12d Model.

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12d Model's ability to handle very large datasets combined with flexible and comprehensive 3D analysis and modeling tools make it perfect for a wide variety of environmental projects.

Existing workflows can adopt 12d Model easily as it allows users to directly interface with GIS systems and most software packages and file formats.

Why Choose 12d?

- Powerful data processing & intelligent functionality.
- Modular, easy to update & completely customisable.
- Seamless integration with major industry software and hardware.
- Used in over 55 countries worldwide.
- Friendly support & training from industry experts.

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