

Autodesk® Revit® MEP in High-Voltage Power Substation Design

Roy Qian – Beca Group

MP3578 This class presents a real-life case study of a successful power substation design project using Autodesk Revit MEP software. It not only covers normal mechanical, lighting, power, security, hydraulic, and fire protection design, modeling, and documentation, but also introduces innovative ways of designing high-voltage cables in tight 3D building and tunnel spaces to meet the strict bending radius requirements. The solution provided some unprecedented methodology for high-voltage substation designers to resolve coordinated multidisciplinary 3D design issues. The methodology readily takes into account bending radius, electrical clearance, cable joints, site work, high-voltage cable position alternating and penetration in tunnels, high-voltage cable connections to geographic information systems (GIS) and transformers through conduits and cable trays, lighting, and ventilation design.

Learning Objectives

At the end of this class, you will be able to:

- Use Revit MEP as the core of an integrated approach for designing high-voltage substations
- Use flexible pipes to simulate high-voltage cables
- Overcome the documentation constraints of Revit MEP
- List things to consider carefully when doing multidisciplinary coordination

About the Speaker

Roy is currently Autodesk® Revit® MEP Senior Specialist at Beca Group, working on Beca's global BIM strategy development as well as providing technical directions of Revit MEP implementation. He has been mainly involved in MEP CAD design drafting, and some software system development projects for the past 17 years. Since early 2008, Roy has successfully led and completed a number of high profile Revit MEP projects across New Zealand and Australia, and has become one of the leaders of Revit MEP implementation in the industry with lots of first-hand project experience. Roy has spoken extensively on Revit MEP topics in the past few years, including: 2011 AU Las Vegas, 2011 AU China, 2011, 2010, 2009 Revit Technology Conferences in Australia.

Email: roy.qian@beca.com

1. Power Substation Design – Integrated in Revit MEP

1.1. Integrated Substation Design with Revit MEP

- Lighting fixtures – fluorescents and flood lights etc
- Light switches, comms and security devices
- Power outlets, switchboard, panels
- Mechanical ducts, plant room, and air conditioning units
- Fire extinguishing equipment, pipes and hydraulic pipes
- Cables ladders for HV and LV systems
- HV cables through tunnels and buildings, connecting to GIS and transformers

1.2. LV Power Reticulation (auxiliary power)

- Place the panels and connect the circuits using Revit MEP's automatic circuiting

1.3. Cable Ladder Design

- Design cable ladders not just for building services (auxiliary power), but also for the HV systems.
- Color Code Cable Ladders (by Filter):
- LVAC power cable ladder
- Protection 1 cable ladder
- Protection 2 cable ladder
- Fibre/Comms cable ladder

1.4. Cable Ladder Design

- Design cable ladders not just for building services (auxiliary power), but also for the HV systems.
- Color Code Cable Ladders (by Filter):
- LVAC power cable ladder
- Protection 1 cable ladder
- Protection 2 cable ladder

- Fibre/Comms cable ladder

1.5. Cable Ladder Design

- Use detail views to document electrically sensitive area.
- Use detail lines/components when necessary.

1.6. Lighting

- Design lighting above the minimum required height in the GIS room.
- Coordinate with other equipment during the lighting design.
- Design lighting suitable for the tunnels.
- Pay attention to the switching logic.
- Pay attention to egress/exit plan for the emergency lights.
- Pay attention to the stair lighting and switching.

1.7. Mechanical – GIS Building

- Running ducts against the walls.
- Exhaust grilles from low level
- Always be mindful of substation equipment
- Design risers and penetrations with full coordination with structure design

1.8. Substation Mechanical Plant Room

- Plant room space can be very tight
- There can be many alternative solution for tight plant rooms, such as split system and fan exhausts.
- Coordinate with structure design closely.

1.9. Hydraulic

- Hydraulic services in substation is minimal
- Remember to keep the 3D model with the schematic changes.

1.10. Fire and Security

- Model foam generator (for transformer fire) in correct size and location.
- Security device follow the egress route design changes.
- 2D drawing is more important for security device placement.

2. High Voltage Cables in 3D – Bending Radius and Electrical Clearance

2.1. High Voltage Engineers' Cable Design – Tunnels, GIS Cable Basement and Transformers

- Design issues:
- Cables to go through tunnels and GIS basement to connect between transformers and GISs
- Limited space in the tunnel, frequent “cross over”.
- Walk way, lighting, fire protection, cable tray allowance in the tunnel.
- Tunnel opening/branching to buildings and to other tunnels.
- Horizontal and vertical bending radius limits.
- Normal radius limits and “under tension” radius limits.
- Structure penetrations.

2.2. High Voltage Engineers' Cable Design – GIS Connection

- Cables to precisely connect to the GIS connectors

2.3. High Voltage Engineers' Design – Structural Penetration

- Penetration is needed for cables to go to transformers and different links of the city.
- Cable cross overs need to be carefully designed to meet both structure penetration and cable bending radius limits.

2.4. High Voltage Engineers' Cable Design – Vertical Bending Radius

- Vertical bending radius is critical for cable cross over and penetrations.

2.5. High Voltage Cables in 2D AutoCAD Design

- Early attempt of using AutoCAD design in 2D proved to be insufficient for this tight space.
- Attempt to use Revit Structure in-place families also proved to be too costly and incapable of frequent design changes.

2.6. Revit MEP 3D Design – Tunnel and GIS Cable Basement

- 3D Design using “flexible pipes” to simulate HV cables.
- You will only see “symbol line” for flexible pipes in 2D, add a 1mm insulation then you can see it look like a cable in 2D.
- No problem for 3D either way.

- Add a shared parameter or simply use the “comment” to identify and filter different circuits.

2.7. Cable Cross-over in the Tunnels

- Cable cross over can be designed with sufficient accuracy.
- Cut sections and details to verify and limit the bending radius.
- “Grip points” of the flexible cable are perfect for fine adjustment.
- Additionally check walk way, lighting, cable tray and fire requirement.

2.8. Revit MEP Cables to Coordinate with Structural Penetration

- Requirement for bending radius must be satisfied before the structure decides the location and size of the penetrations.

2.9. High Voltage Cables Connecting Transformers

- Cut sections and details to measure and document the electrical clearance requirements.
- Cables are modelled to the locations of connection but may not necessarily “hard connect”
- Check the cable bending radius in adjacent areas – tunnels, buildings, penetrations.

2.10. High Voltage Cables – Going Through Structural Piles

- Aim the conduits straight to avoid clashing with the structural piles.
- Use Revit MEP “conduit” system family to model conduits.
- The bending radius of the conduit (fittings) can be explicitly set and they should meet the cable “under tension” bending radius limits.
- Run “flexible pipes” through the conduits, as cables.

2.11. High Voltage Cables – In Shaft and Tunnel

- There are vertical and horizontal bending at the same time for the HV cable in the cable shaft.
- Cables are designed for optimal bending and access for maintenance work.

2.12. High Voltage Cables – In Shaft and Tunnel

- For transition from the shaft to the tunnel, cable supports families are to be created and modelled correctly.
- Adjacent buildings and penetrations to be coordinated.

2.13. High Voltage Cables – Cable Joints Design

- Cable joints to be designed and documented in details.
- Allow straight portion of the cables for joints and fire devices.
- Use “conduits” to simulate “joints”.
- Three phases are rotated after the joints.

2.14. Overview of all the HV Cables – With Cable Schedule

3. Documenting the 3D Power Substation Designs

3.1. Drawing – Drawings with Mixed Levels

- Power substation has many mixed levels or half levels.
- Use “Plan Region” to adjust heights.
- Use sections to document items in the half level area.
- Stair lights are tricky, use 3D to place the “face based” lighting fixtures in the stairs and then annotate on the 2D drawings.

3.2. Drawing Settings – Colors for HV Cables, Mechanical Ducts and Cable Ladders

- Use filters extensively to control colors in a logical and intuitive way.
- Color drawings saves time, which is money too.
- Use 3D views in the drawings extensively, to improve communication.

4. Multi-disciplinary Design – What to Consider?

4.1. Frequently Required Cross Discipline Coordination

- Cable ladders vs. mechanical ducts, substation equipment.
- Lighting fixtures vs. substation equipment, fire egress route.
- Mechanical ducts and louvres vs. structure beams, penetrations, wall openings, substation equipment.
- Security devices vs. fire egress routes.
- HV cables and conduits vs. structural penetrations, piles, cable ladders, walk (cart) ways.

4.2. Navisworks and Coordination Communication

- Navisworks is the focal point of all the coordination.
- Engineers of all the disciplines should be able to use Navisworks – HV and LV electrical engineers, lighting engineers, mechanical engineers etc.
- Open and timely communication is required.
- Dedicated “3D View: \$NAVIS EXPORT” should be setup in every model for frequent and quality export.