Location and alignment devices

Status Work in progress

Things to discuss:

- What types of components is interested in standardising on?
  - Is it more important to come up with general system designs with all features incorporated or sand-box type solutions where teams can pick and choose.
- Benefits and disadvantages with rollers and guide rods.
- How to control tilt.

Section Intro

Links

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During RH operations, it is important to ensure that module self-engages and aligns during installation and extraction.

The RH equipment (i.e. overhead cranes in this case) shall not be relied upon to be ‘accurate’ in its movements and positioning. It can be assumed that the crane will be able to move smoothly and slowly, however it will not be able to move accurately to a given co-ordinate in an absolute reference system.

Modules shall be designed to be self-aligning during installation and extraction. Alignment shall be gradual and phased so that one degree of freedom is constrained at a time.

The design of a location device shall take into account the realistic capture range of the mating features and fasteners.

The alignment shall not be over-constrained and shall be toleranced to accommodate in-service distortions as well as manufacturing variations. Modules shall be designed to prevent wedging and jamming of parts.

Consideration should be given to what RH equipment and tooling will be used to perform the task, when designing the module alignment system.

The orientation of the module shall be considered, i.e. installation on the ceiling or on a vertical wall is complicated by the gravity vector. Supporting indicators such as built-in spirit levels should be used to aid module orientation where possible and applicable.

Unambiguous sensors/indicators should be used where practicable to show that module items are fully engaged (e.g. lining up features on mating items).

Locations devices shall be designed such that it is impossible to mate modules incorrectly (e.g. asymmetric dowels preventing wrong orientation). Visual cues should also be used where practicable to assist correct assembly.

Careful consideration should be given to choosing the correct datum and then tolerancing all module items accordingly with respect to that datum.

Jamming and Wedging

From the outset jamming and wedging conditions must be understood so it can be avoided in the design of alignment features for modules.

Jamming occurs when an external force causes two plant items to lock-up during assembly (see Figure 1). When the external force is removed, these forces disappear and the two items are no longer jammed. A jamming condition can be recovered by removing the external force, however, the design of RH locating devices shall minimise the possibility of jamming.

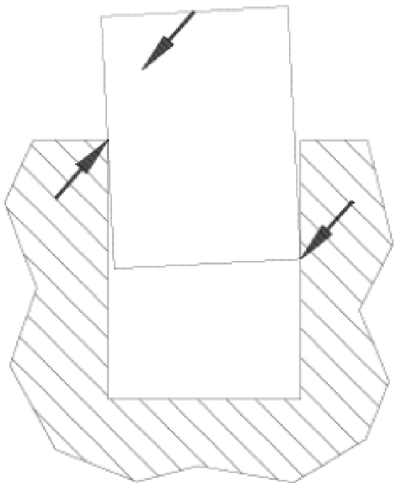

Figure 1 – Jamming

Wedging occurs when forces between the two assembled parts are internally balanced – i.e. with no externally applied force (see Figure 2). When this occurs an additional force (whose magnitude is difficult to accurately quantify) is required to deform the items in order to release them. A wedging condition is difficult to recover, therefore, the design of locating devices shall eliminate the possibility of wedging.

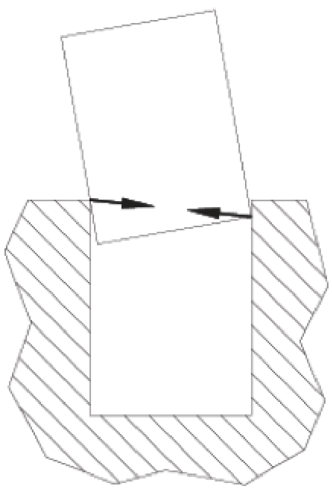

Figure 2 - Wedging

Kinematic constraint

A free body that is to be located by means of RH has a total of six degrees of freedom (DoF), three translations and three rotations (Figure 3). The purpose of locating devices is to progressively reduce the number of degrees of freedoms of the handled module to ensure that the mating process is carried out in a controlled manner without damage.

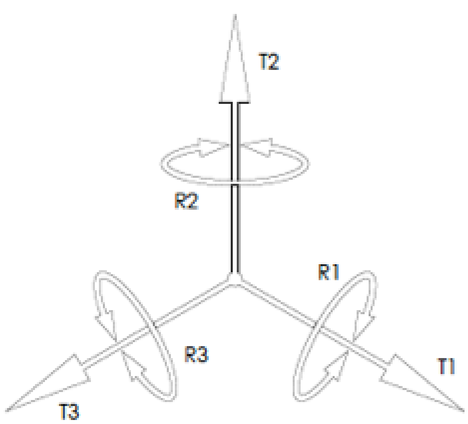

Figure 3 - Six degrees of freedom

An example of an RH compatible assembly using the kinematically constrained staged approach is given in Table 2 and Figure 4. At each stage of location, the number of DoFs has been reduced until the plant item is fully installed (DoF = 0). This general principle of staged kinematic constraint should be applied when developing a RH location device.

For each application, the method of kinematic constraint should be clearly defined. The number of steps required is dependent upon the complexity and required accuracy of the location device.

Location features shall be oriented vertically to avoid placing dowels in shear.

Table 2 - Staged kinematic constraint

Step	**DoF’s**	**Type**
1. Module held in free space	6	3 Translation 3 Rotation
2. Module located on dowel ball-end	4	1 Translation 3 Rotation
3. Module located on single long ball-ended dowel pin	2	1 Translation 1 Rotation
4. Module item located on second short dowel pin	1	1 Translation 0 Rotation
5. Module fully in contact with mating face	0	0 Translation 0 Rotation

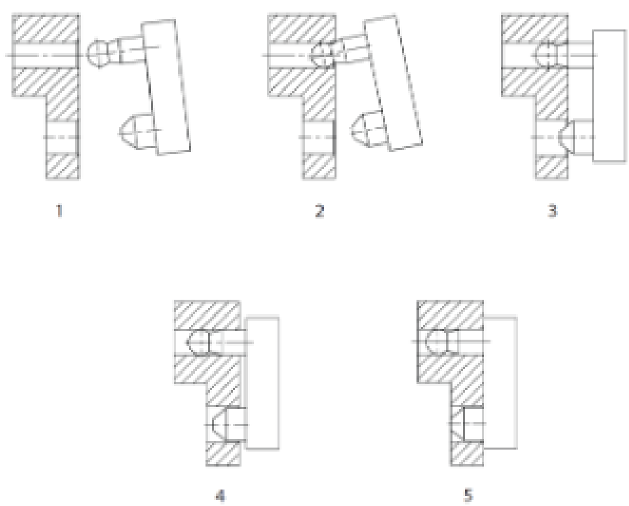

Figure 4 - Kinematic constraint stages

Edge guides

Edge guides are a simple method of providing module location. In a single plane three points of contact are used to define the correct position and two perpendicular forces are required to fully constrain the item.

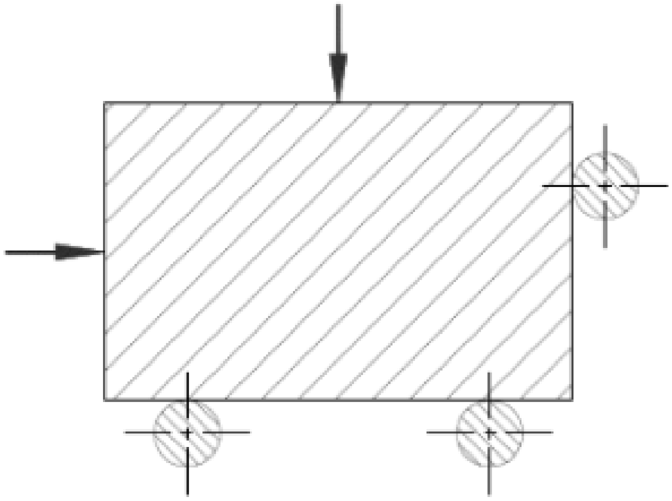

Figure 5 - Three-point edge location principle

The plane of location can be either vertical or horizontal. When the plane is vertical, careful consideration must be made to the applied forces (both static weight and dynamic loads) on the supports.

Edge guides are particularly appropriate where a clear view of the installation process is required as the supports are external to the located plant item.

Edge guides are not preferred within the ESS common shielding bunker since all remote handling operations are foreseen to be vertical using crane based solutions (i.e. it is difficult to add a second load).

Guide pins

This sections describes the use of guide pins/rods in juncture of handling misalignment. Guide pins/rods can be replaced by rollers or equivalent if it better suits the specific design. The rollers shall follow the same design considerations as guide pins.

Guide pins or rods should be used where a large misalignment needs to be reduced. This type of pin should be used to provide coarse initial location as the first stage in reducing the DoF's of a located module. The guide pin is used to reduce the initial misalignment to bring the dowel pins within their capture range which themselves provide accurate final location (Figure 6).

Guide pins can be mounted on either the module or the mating structure depending upon the specific requirements of the design. The length of the guide pin is determined by nature of the interface (i.e. not damaging surrounding equipment) and the available visibility during assembly – a longer guide pin is required where visual access is poor. Typically, the guide pins are long enough to clear the components from the surrounding sensitive equipment and/or allow for easy engagement during installation. Neighbouring instruments and infrastructure should be considered as well as instrument internal equipment.

If more than one guide pin is used, to further constrain the DoF, they should be of different lengths to gradually reduce the DoF. Pins should be sufficiently tapered to aid installation without becoming a personal hazard.

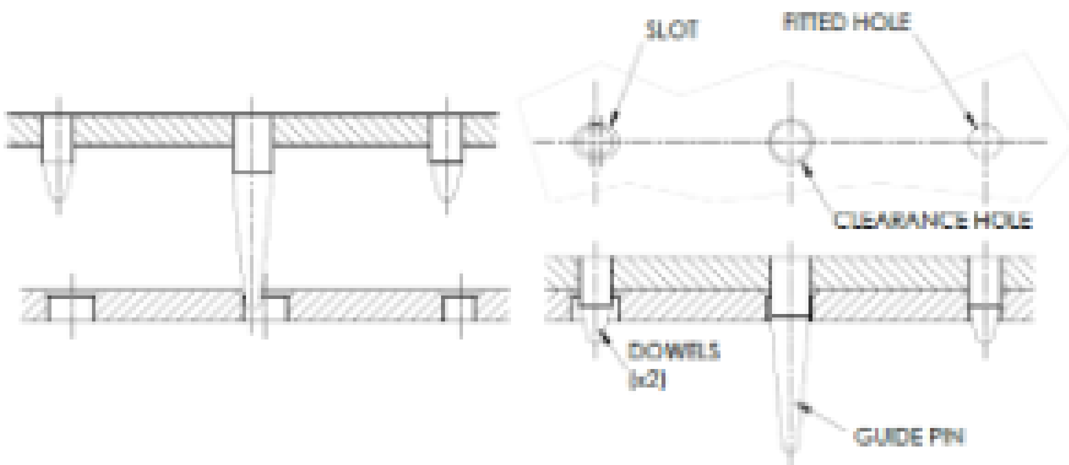

Figure 6 - Guide pin

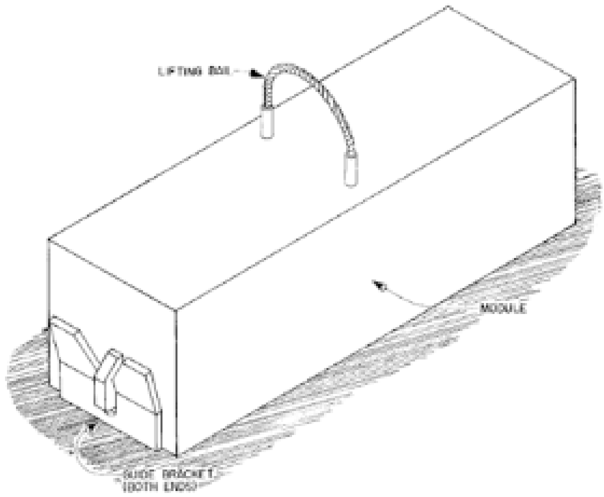

Figure 7 - Guide bracket example

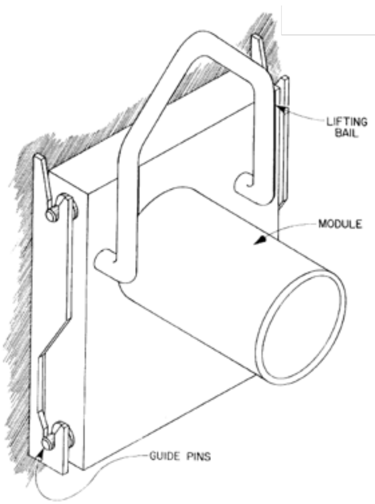

Figure 8 - Vertical hanger bracket example

Dowelling arrangement

Dowels provide an accurate method of final location for two mating items. A minimum of two dowels and one contact surface is required to fully constrain a module.

The proportions of the dowel (length and diameter) must be sized appropriately with respect to the method of manipulation used and the anticipated loads that could be applied during assembly.

Dowels should also be used to protect against side loads on mechanical fasteners during installation and in-operation. Thread damage and seizure may result from this type of loading and this risk should be minimised during design.

A limitation of this method of location is that the dowel(s), contained within the body of the module, are usually obscured during engagement. This method, therefore, relies upon good kinematic constraint and good visibility.

The generic parallel dowel pins are generally used in pairs to fully constrain two mating surfaces. One dowel located in a fitted hole eliminates two translational DoF's and the second dowel in a short slot eliminates a rotational DoF about the fitted hole (see Figure 9).

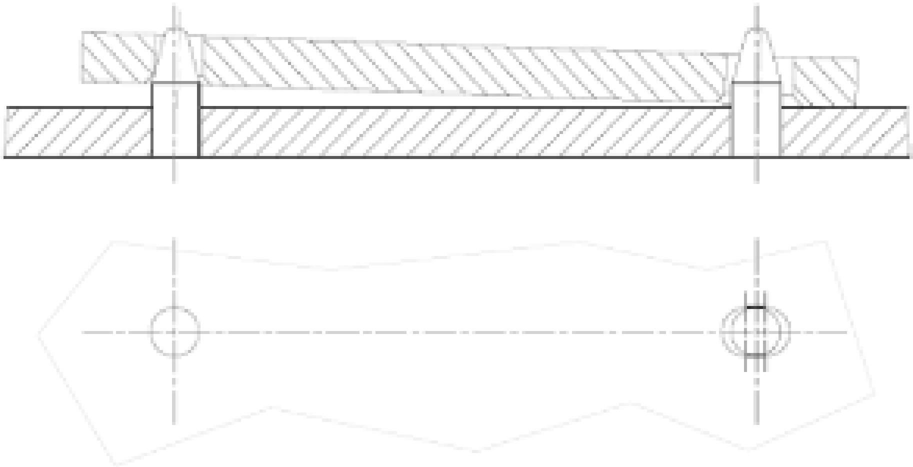

Figure 9 - Parallel dowel pin

Dowels should be as short as possible to provide adequate location and strength whilst minimising the risk of jamming. In addition, the profile of the nose of the dowel should be such that it increases the capture range and also avoids jamming.

Cylindrical dowel pins should be spaced apart as far as possible in order to minimise jamming of the pins when angular misalignment occurs during assembly.

Tracker points

Modules requiring survey and alignment during installation or operations shall contain survey point interfaces according to ESS-0011484.

Related Articles

References

Contributors

Related JIRA issues