Civil and Structural Asset Management in Oil and Gas Plants

by *Ir. Mohd. Nazri Mustafa*

THIS article describes the procedure to manage civil and structural assets in oil and gas plants. The main objective of having an effective asset management program is to avoid unplanned shutdown due to the sudden failure of civil and structural facilities or unfit facilities which pose possible safety hazards.

The current status of these facilities needs to be recorded and continuously monitored. Cracks propagation needs to be studied properly to establish the actual cause of the problem. There are cases where cracks were repaired repetitively without adequately analysing its cause. By establishing the pattern of cracks over time, the cause of the cracks could be pinpointed.

The following program as presented in this article is in line with the concept of Preventive Maintenance as an effort to avoid unplanned lost of production opportunity which could affect a company's financial capability.

As Preventive Maintenance is based on the statistical/historical data of meantime to failure, the plant owner could predict, based on the pattern of defects, the best and most economical time to repair, strengthen or replace the structures or facilities to avoid serious defects that could hamper the plant's operation.

CIVIL AND STRUCTURAL ASSETS:

Civil and structural assets in oil and gas plants can be categorised into the following:

- Structures which include all major and minor structures (R.C. and steel) supporting all types of equipment and piping. This category includes superstructures as well as substructures for both onshore and marine structures.
- Buildings which include process and non-process buildings. Some of the process buildings are designed as blast resistant buildings based on their function and location, *e.g.* control building.
- Shelters which include all portal frames and steel shelters.
- Surface and underground drainage system.
- Other miscellaneous civil works which include platforms, road, fire proofing, *etc*.

In line with the design life of an oil and gas plant which is between 20 to 30 years, civil and structural assets are also designed to fulfil the target design life. Corrosion rate and protection, concrete cover, carbonation and chloride intrusion rate are among the important items that need to be considered.

ASSET MANAGEMENT PROCEDURE:

In order to effectively manage an asset, the changes in its characteristic and properties over time should be fully understood. In normal circumstances, an asset management procedure will first be established by the plant owner. The document will provide guidelines for the following civil and structural items:

- The list of possible defects for concrete and steel materials.
- Categorisation of defects, *e.g.* cracks (major, minor, structural, non-structural, active, non-active). Other defects such as the corrosion of steel members shall not be ignored and shall be described appropriately. The category of corrosion (severe, medium and mild) and the type of corrosion (uniform, galvanic, crevice, stress and erosion) shall be recorded in order to accurately identify the cause of such corrosion.
- List of DT and NDT for concrete and steel (for detailed inspection). The common DT and NDT for concrete and steel such as In-situ Ultrasonic Pulse Velocity Measurement, Covermeter Measurement, Ultrasonic Test, *etc*, shall be clearly listed in the inspection form to facilitate further investigation.
- Visual inspection forms for all civil and structural assets. The inspection forms will record all visible defects, the need for DT and NDT, photos of defects and recommendation by the inspector and endorsed by the engineer in-charge.

The prioritised items of inspection and frequency of inspection will depend on the criticality of the particular civil and structural assets. The assets are normally ranked high or low priority based on the following criteria:

High priority assets:

- Foundations and structures supporting major equipment and piping of which shutdown will result in significant operation loss.
- Blast resistant control building and substation.
- Major underground services (drainage, fire water, *etc*) of which non-functional will give rise to HSE issues.

Low priority assets:

- Miscellaneous foundations and structures for less important equipment and piping.
- Miscellaneous platforms for access and maintenance.
- Surface drain, roads and paving.
- Miscellaneous shelters and buildings.

It is always recommended that plant owners adopt the Preventive Maintenance approach as opposed to Corrective and Reactive Maintenance. This will produce a safer working environment with a proper budget plan for repair work.

In general, inspection frequency is divided into several categories:

- Immediate inspection (in the event of visible serious defects or following an exceptional event that could harm the integrity of the assets. An example of such a situation is when the structure is subject to fire which warrants immediate inspection).
- Short term inspection (once every 3-6 months).
- Medium term inspection (once every 1-5 years).
- Long term inspection (once every 10 years).

It is recommended to adopt the short term inspection for all civil and structural assets. A walk-through inspection with adequate engineering knowledge of structural behaviour and possible defects combined with the appropriate inspection forms will be sufficient to identify any anomaly on structures and other assets. Structural settlement, uplifting, cracks, spall, corrosion, etc, could be detected by the naked eye. If needed, further detailed inspection to check structural tilting, deflection, sagging, settlement, etc, could be performed. Survey equipment is commonly used to measure the verticality of a tall structure, deflection of horizontal members, foundation settlement, *etc*. Levelling tools are also used to monitor structural verticality and horizontal movement. Demec Gauges are used to monitor cracks movement and propagation, while vibration devices are used to measure acceleration, velocity and displacement due to vibration.

The record of such periodic inspection will be kept in the database to form an inspection history for future reference.

Structural Integrity Assessment is one aspect of Asset Management. Structural Integrity Assessment is normally performed due to the following reasons:

- Change of use of the structures
- Extension of structural design life
- Presence of apparent defects
- Change of applied loads
- Structural modifications
- Structural damage due to fire, blast, impact, *etc*

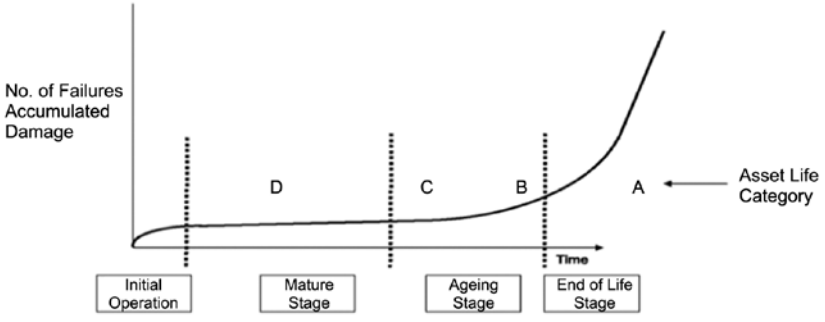

Figure 1: Asset Life Categories over life span of facilities

Structural Integrity Assessment involves structural analysis and design review, and the result will be in the form of Structural Utilisation Ratio, Reserved Strength Ratio and Remnant Life Assessment. Structural Integrity Assessment is important in order to plan the structural strengthening and modification for future expansion.

Based on the results of the visual inspection, analysis of the DT and NDT result and Structural Integrity Assessment, the prioritised plan and budget could be made on the items based on their criticality ranking:

- Category A : Immediate replacement needed
- Category B : Major repair and strengthening required
- Category C : Minor (but significant) repair required
- Category D : Routine maintenance required
- Category E : Extensive/specialist study required

The categories are shown in the asset lifecycle in Figure 1. With the aforementioned categories, the assets in oil and gas plants could be effectively managed in line with the Preventive Maintenance concept.

REAL CASE EXAMPLES OF ASSET MANAGEMENT ISSUES

Materials deterioration though gradual, but if left unattended, could pose serious problems to plant operation. A real case example is the development and propagation of major cracks due to alkali-silica reaction which has placed an equipment support structure at one of the plants under the high risk category of structural failure (refer Figure 2). Continuous repair, strengthening, monitoring and analysis needs to be done to ensure the structure could last the design life as originally intended. The economics between the total reconstruction of the structure and continuous repair of cracks and structural strengthening was studied. Based on the designed life of the plant, severity of defects and rate of cracks propagation, it was decided that the structure was able to perform its function provided all defects were continuously monitored and repaired accordingly. Structural strengthening was provided in line with the recommendation based on structural modelling and analysis.

Structural defects could also be caused when the applied loads are greater than designed. In such a case, the root cause of the problem shall be rectified prior to the rectification of structural defects. This relates to another real case example whereby a reinforced concrete structure supporting major equipment has major and minor cracks due to excessive equipment vibration (refer Figure 3). Modifications on the equipment to reduce the vibration amplitudes and avoid resonance were given the highest priority. Proper vibration monitoring, structural modelling and analysis was

Figure 2: Cracks on structures supporting equipment.

done and, based on the result, the source of the cracks was due to excessive vibration during start-up and shutdown. During normal operation, vibration was in normal mode. New cracks re-appeared over repaired cracks after some time which indicated that the problem remained even though the cracks had been repaired. When equipment vibration was reduced by modifying the inlet and outlet details, the cracks propagation stopped.

Figure 3: Cracks due to excessive vibration of equipment.

The cost profile of periodic repair to ensure structural safety was calculated for the next 20 to 30 years in line with the extended design life as decided by the plant owner. The cost could be as high as RM50-RM100 million depending on the amount of repair and strengthening work, and unit shutdown involved.

CONCLUSION

Having an effective asset management program will definitely reduce the overall cost of plant operation by avoiding unplanned shutdown due to unfit facilities. It is always the objective of any oil and gas plant to ensure that safety is upheld and repair is done before it is too late. Failure to exercise proper asset management will result in money and time lost due to unnecessary repair, strengthening and shutdown. It is also important for the plant owner to adopt an effective asset management policy in view that not all defects are visible. Invisible defects such as carbonation and chloride intrusion could cause serious damage to the structure and compromise its overall integrity. Failure to anticipate potential defect could result in serious risk of failure. ■