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Project Construction Surveying Procedure

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1.0 PURPOSE

This procedure defines the work process for site construction survey operations.

This procedure applies to works performed under all Government construction projects executed throughout the Kingdom of Saudi Arabia.

For the purposes of the Construction Management Procedures the Project Management Company is the Entity Project Management Organization (EPMO) appointed by the Entity and references prefixed with “Site”, such as Site Construction Department, Site Engineering Department, represent the Project Management Company at Project level, on construction sites.

2.0 SCOPE

This procedure covers best practice that should be applied where Construction Contractors are responsible for all survey activities or where a dedicated Survey Contractor is contracted and appointed to work alongside the Construction Contractor.

3.0 DEFINITIONS

Definitions	Description
Survey Work Request (SWR)	A form (paper or digital) submitted to the survey department by a requestor from another department or discipline or by the Survey Department itself; the SWR formalizes and provides details for the requested survey activities and provides the mechanism for tracking and locating survey work performed.
Calibration Baseline	A multi-point reference line, which is accurately established early in the life of the project or has been previously established for the purpose of checking the accuracy of tapes, electronic distance measuring (EDM) equipment and other survey equipment.
Settlement Monitoring Surveys	Controlled monitoring of a particular surface or structure, to determine the extent of any vertical and/or horizontal movement.
UTM	Universal Transverse Mercator
GPS	Global Positioning System
GNSS	Global Navigation Satellite System
DCN	Drawing Change Notice
Entity Project Management Organization (EPMO)	An Entity Project Management Organization, this is an integrated team that comprises the Entity and its PMC responsible for managing all the Entity’s projects.
Enterprise Content Management System (ECMS)	An information management and collaboration platform for managing and controlling Project documents and Entity records
Construction Contractor	The Main or Principal Contractor responsible for undertaking the Construction Works on the Project. Individual(s) or firm(s) engaged in the construction of buildings, either residences or commercial structures, as well as construction activities such as paving, highway construction, utility construction and landscape installation.
Site Contracts Department	Department within the Project Management Company that is responsible for administering Contracts.
Site Construction Department	Department within the Project Management Company that is responsible for Construction activities/operations.
Site Engineering Department	Department within the Project Management Company that is responsible for Engineering or design activities/operations.

4.0 REFERENCES

1. EPM-KCE-PR-000007 Project Construction As-Built Drawings Procedure
2. EPM-KCQ-PR-000006 Project Construction Control of Non-Conforming Items Procedure.

5.0 RESPONSIBILITIES

5.1 Construction Contractor

The Construction Contractor is responsible for providing sufficient survey resource to ensure the Works are built in accordance with the contract requirements.

5.2 Site Construction Department

The Site Construction Department is responsible for oversight of the Construction Contractor to ensure works are completed in accordance with the project requirements and coordinated with adjacent project or stakeholders. Where the Construction Contractor is at risk of not meeting the project requirements the Site Construction Department will coordinate mitigation measures with the Construction Contractor or other Survey Contractor to resolve the issue.

6.0 PROCESS

6.1 Planning

6.1.1 Approved Coordinate Reference System

There are currently two accepted coordination systems used by the Ministries in the Kingdom of Saudi Arabia:

- Ain El Abed 1970 with the associated UTM (Universal Transverse Mercator) Zone

  The Ain El Abed 1970 is the mathematical model of the planet Earth and UTM Zone is the Universal Transverse Mercator Zone North map projection where easting and northing coordinates are displayed. The heights/elevations are referenced to Jeddah Datum 1969. For example, Ain El Abed 1970 UTM38N is the coordinate system for the UTM Zone 38 where Riyadh is located. Depending on the location in the Kingdom of Saudi Arabia, other UTM Zones have to be used. Examples of Zone location are shown in the map below.

- World Geodetic System 1984 (WGS84)

  The World Geodetic System 1984 (WGS84) and Google Earth are currently using the same geographic coordinate system

WGS 1984 is a geographic coordinate system, and UTM is a projected Cartesian coordinate system. Through GPS/GNSS surveys the geographic WGS84 coordinates are observed and usually transformed to the local UTM systems such as Ain El Abed 1970 UTM38N or another UTM zone in Saudi Arabia. Transformation parameters are required to transform WGS84 to UTM and vice versa. Daily works are usually carried out in Cartesian coordinate systems, eg, UTM.

For transformations of coordinates in Ain El Abed 1970 UTM Zone to WGS84 and vice versa appropriate software, eg, ESRI, ARCMAP, Micro station, etc. has to be used.

All responsible parties should ensure that:

- All coordinates, models, drawings and maps are referenced to one of these systems.
- All Construction Contractor surveys are reported in accordance with one of these systems.
- All coordinate lists and drawings indicate the coordinate system used, either Ain El Abed 1970 or WGS84

6.1.2 General

The Site Construction Department should ensure that a Construction Contractor Lead Surveyor (LS) is engaged as early as possible allowing sufficient time to, at a minimum, accomplish the following:

- Prepare a Project Survey Plan
- Coordinate the procurement and mobilization of survey tools and equipment
- Establish the Project's calibration baseline
- Initial Setting-out/Stake-out/layout surveys for construction works
- Locate, establish and verify the primary control points
- Coordinate with the Site Engineering Department team the details regarding digital data transfer
- Participate in the selection of the surveyors and technicians
- Perform earthwork-related survey operations, including staking for excavation and backfill, and topographic surveys for earthwork quantity calculations and design purposes.

6.1.3 Project Survey Plan

Before starting construction activities, the Construction Contractor should prepare the Project Survey Plan and require that all survey operations on the project adhere to this plan. This plan addresses standards, tolerances, settlement monitoring program, required equipment, and direct-hire/subcontractor, etc.

6.1.4 Settlement Monitoring Program

Complex projects may require comprehensive monitoring of structures for movement and/or settlement. The Construction Contractor should confirm that the Project Survey Plan addresses all structures that require monitoring and the duration of monitoring.

6.2 Survey Support for Construction Operations

Typical construction operations that require survey support include, but are not limited to:

- Location of initial site boundaries and topographic survey
- Establishment of horizontal and vertical control for the site
- Collection and recording of as-built data or check survey data, either for tying into existing facilities or upon completion of new systems or facilities
- Settlement monitoring of structures
- Establishment of reference points on structures to control construction

The above items may be undertaken by the Construction Contractor, by a Surveying Contractor or by directly employed survey team as defined in the Project Survey Plan.

Generally, the Construction Contractor shall undertake the following activities:

- Earthwork related survey operations including staking for excavation and backfill, and topographic surveys for earthwork quantity calculations
- Concrete related operations including layout of formwork, pre-placement verification of line and grade of forms and embedded items, monitoring of forms and critical embeds during concrete placement, setting of brass caps or other monuments for future survey control, and recording of as-built locations following concrete placement
- Steel erection operations including recording of anchor bolt locations, setting of shim packs for column base plates, plumb checks of columns, and structural steel as-builts
- Establish reference points to support and perform layout of mechanical, piping and electrical commodities, and the setting of equipment
- Final grading and paving operations
- Hydrographic surveys

6.2.1 Survey Work Requests (SWR)

All survey work, except scope, included as part of the Construction Contractor contract requirements, shall be requested either in writing or electronically utilizing a Survey Work Request (SWR). A sample proforma SWR is shown in Attachment 1 - EPM-KCE-TP-000009 Project Construction Survey Work Request Template (Sample).

The Construction Contractor's Lead Surveyor (LS) is responsible for the administration of the SWR system.

- The Lead Surveyor shall determine the priority for implementing survey requests according to the date of receipt and the current site priorities.
- A minimum of 24-hours advance notice should be provided when requesting survey work. When this is not possible, the LS shall schedule the work according to the project priorities.
- The requestor shall submit the SWR with any relevant documents, current drawings or sketches to the LS for implementation. It is the responsibility of the requestor to attach copies of any drawings (current revision) that are part of the SWR.
- Before the survey crews perform the survey, the requestor shall inspect the area where the survey will occur and confirm that it is ready (ie, area has been cleaned up; the craft is available, etc.).
- Survey work which is large in scope/size or that will take long periods of time to complete shall not be requested on a single SWR, unless discussed and agreed to by the LS, but instead shall be requested in phases. How to divide these SWR's should to be discussed with the LS prior to start.

  For example: a request that has-slab 1 through 32 on grid lines A through F be dimensional checked can be distributed over three or four SWRs. This would assist the survey team to

effectively manage their workload and to accurately maintain the amount of electronic data generated.

- An SWR log shall be maintained (electronically) by the Lead Surveyor. It will be used to monitor and track all SWRs. If using paper SWR's, the approved SWR Log should be available for download from the shared-drive or Enterprise Content Management System (ECMS). The SWR Log and all survey electronic data files shall reside on a dedicated survey folder within the project server.
- SWRs are not considered quality documents and may be destroyed at the end of the project unless project-specific requirements dictate their retention.

6.2.2 Calibration Baseline

To check the accuracy of survey equipment at the construction site, the LS shall establish a site calibration baseline using a recently calibrated Electromagnetic Distance Measurements or static GPS survey or laser tracker. Site instruments will be checked against that baseline. Instrument measurements should be checked on a periodic basis but no more that 3-6 months after calibration as agreed to by the Site Construction Department. Originals of all baseline instrument check certificates and their corresponding baseline check sheets shall be made available for inspection upon request by the Site Construction Department.

At a minimum, the baseline shall consist of three monuments, (Stations A, B & C) in line with each other.

- Station A shall be the first monument
- Station B shall be 30m from Station A
- Station C shall be at least 152m distant from Station A

Where possible, the instrument calibration baseline monuments that are used for checking the survey instrument should not be part of the project's primary survey control network.

6.2.3 Calibration Collimators

Depending on the scale of the project the contractor may establish on mega-project sites a 'calibration lab' with calibration collimators to check the accuracy of the survey equipment angular measurements. The same collimators can be used to check and adjust the digital and automatic levels.

External authorized equipment service agent shall be identified to carry out mandatory external periodic calibration and service for all eligible project survey equipment.

Calibration labels indicating the last and the next calibration date shall be attached to the instrument at all times. A calibration schedule shall be prepared for all instruments which are subject to specified periodic calibration.

6.3 Computations

All survey computations will be performed using suitable project approved software. Coordinate data generated by other means (such as manually with a calculator) shall be recorded in a field book or computation sheet with the appropriate comments identifying the computation method.

All calculations shall be checked and verified by separate independent calculations.

Note: Care shall be taken to ensure that concrete, structural steel and architectural drawings are cross-checked for inconsistencies or dimensional conflict. It is important to ensure the latest design information is available (including field change documents, DCNs, revised drawings) and to cross-check any questionable coordinate or elevation information against other design documents and/or the model.

Discrepancies that cannot be resolved shall be brought to the attention of the LS and Construction Contractor for resolution with the Site Engineering Department.

6.4 Recording of Survey Data - Field Books and Electronic Files

Observations shall be recorded either electronically on the instrument's internal memory system or in a field book.

6.4.1 Documenting Survey Data

Field Books and/or electronic files shall be used to document all survey work activities including:

- A daily log of survey activities
- Manual survey calculations and observations

All field books shall be uniquely numbered using the established project numbering system. Field books shall be stored in a secured manner by the LS for filing in the project records. Field books shall be completed as follows:

- The first three pages in each field book shall be reserved for an index of the contents that shall be completed before the field book is forwarded to the LS for filing.
- Field book pages shall be numbered consecutively and the page following the index pages shall be numbered page 1.
- The SWR number, date, crew, weather, temperature, barometric pressure and instrument data shall be entered into the field notes.
- Following best practices, erasures are not permitted in field books. Corrections to entries shall be made by drawing a single line through the information requiring correction and entering the revised information above or beside the original entry (this is an example of a ~~strike through~~). The individual revising the information shall initial the revision adjacent to the strike through.
- Level loops utilizing an automatic level shall be recorded in the field books and upon completion the data reduced and checked. Following best practice, checking of sums is recommended.

6.4.2 Electronic Survey Data

All electronic survey data files shall be maintained on a dedicated survey folder that resides on the project server, with the appropriate backup

- Survey raw data (field data) shall be stored in the raw data folders. This data shall by no means be modified.
- All data files (excel files, drawing files, coordinate lists etc.) which come to existence in the course of the post-processing shall be stored project job files.
- Storage of survey data shall be in an approved systematic way for traceability.

6.5 Survey Control

The LS shall prepare and maintain a current site map showing the descriptions, positions and coordinates of all primary and secondary survey control points (monuments).

A Surveyor Report should be provided by the Construction Contractor upon establishment of Horizontal and Vertical Survey Control to the Site Construction Department and transmitted to Site Document Control for filing in the ECMS and also kept in an independent SWR. This report should include, but not be limited to, a description of the installed survey control, any checks made, adjustments made, closure errors, means and methods of adjustment or non-adjustment and why. The checked primary and secondary control point information shall be made available to all parties that may require to make use of this information.

6.6 Survey Monuments

The LS shall determine the appropriate number of survey monuments required to support the requirements of the project. Survey Monuments for construction work shall be divided into three types:

Primary Monuments - are intended to be permanent and should remain stable for the lifetime of the project. A minimum of four Primary Monuments shall be established in accordance with standard good surveying practices. Larger projects may require additional monuments be established.

Secondary Monuments - are intended to remain stable throughout the construction duration

Tertiary Monuments - are intended to only be stable for a limited time.

6.6.1 Protection of Survey Monuments

All monuments should be highly visible and protected from damage by vehicle / equipment etc.
Primary and Secondary monuments are critical to the project therefore should be protected by installing steel bollards (or equivalent) around them.

6.6.2 Control Points

The Construction Contractor shall establish Control Points for coordinating and laying out the work.

Control Points should be set at locations where they can be easily utilized repeatedly in the future for additional layout and as-built surveys. Occupying the same setup point or as close as possible to a prior free station position will ensure consistency and reliability and reduce compounding accumulation of errors.

6.6.3 Site Verification Surveys

6.6.3.1 Primary Control Verification

The position of all primary site control points must be verified by the Construction Contractor before commencing construction. Any discrepancies from the published positions of the site's primary survey control shall immediately be brought to the attention of the Site Construction Department for resolution.

6.6.3.2 Verification of Site Conditions

The existing topography including utilities, structures, especially any tie-in points, must be verified before starting construction. Any discrepancies from the published positions of any of the existing features on the site or features associated with the scope of future construction shall immediately be brought to the attention of the Site Construction Department for resolution.

The topographic survey will be the basis for generating the existing site contours map, which will serve as the baseline for any earthwork volumes computations

6.7 Office Procedures

6.7.1 Digital Data Management

The LS shall receive the digital design data from the Site Engineering Department; and shall transfer the data from the design model to the approved project survey software which will then allow it to be downloaded into the field instrument(s) control units. The process of downloading the design data digitally instead of manually eliminates opportunities for the data to be entered incorrectly.

6.7.2 Survey Report

An executed and completed SWR shall be report in a systematic manner under a unique SWR or Survey Report number, and to make sure all raw data and job data files are store in their proper locations. The LS

shall coordinate, supervise and check this to ensure that all project survey work data is comprehensively archived.

6.8 Field Procedures

6.8.1 Safety

The LS will take all the necessary steps to ensure that all construction survey operations are performed safely and all survey personnel receive all required safety training. The Construction Contractor is responsible for completing a Method Statement and Risk Assessment or any other similar safety documentation required by the project safety procedure before commencing any work.

6.8.2 Field Data Management

All data obtained or staked out in the field will be transferred to the main survey computer (CAD station) by the field crews on a daily basis.
Data collected in the field will be processed and delivered digitally to the Site Engineering Department team and other users as required. The LS shall arrange for the transfer of the data from the field instruments control units into the design models utilizing the approved project survey software.

6.8.3 Verification of Construction Contractor's Work

The project should perform verification surveys on a portion of the work of the Construction Contractors to verify the quality. This is performed in accordance with EPM-KCE-PR-000007 Project Construction As-Built Drawings Procedure, at the direction of the Site Construction Department by submitting an SWR listing the work that requires verification.

If defective work is discovered during these random checks, the requesting party may request additional verification checks be performed. Non-conformances shall be documented in accordance with EPM-KCQ-PR-000006-Project Construction Control of Non-Conforming Items Procedure.

The verification works can be undertaken by the Project Management Company in-house surveying department or can be undertaken by an independent specialist surveying company employed by the Project Management Company.

6.8.4 As-Built Surveys

When as-built data is required, it shall also be managed electronically so that the data can be transferred electronically to the Site Engineering Department for use in the appropriate topographic or design application. If electronic data is used to transfer as-built information, the Construction Department will coordinate the data format with the receiving organization.

The positions of all underground structures and utilities, both temporary and permanent, shall be captured before backfilling.

6.9 Settlement and/or Monitoring Surveys

Permanent monitoring points will be installed inside or outside of structures as required. These points shall be installed and initial observations must be recorded before the start of construction activities that could cause ground movements in order to establish "baseline" conditions.

These points shall be monitored for settlement or movement as indicated on the SWR.

The monitoring points shall be located a sufficient distance from the area being monitored so they will not be affected by any movement or settlement of that area.

Reports detailing monitoring activities shall be generated and submitted at the frequency requested and to the individuals indicated on the SWR.

The SWR shall include a clear chain of command listing the personnel to be notified in case movement is detected. The instructions should indicate clearly what degree of movement would require more frequent monitoring and what degree of movement would require immediate notification.

7.0 ATTACHMENTS

1. EPM-KCE-TP-000009 - Project Construction Survey Work Request Template

Attachment 1 - EPM-KCE-TP-000009 - Project Construction Survey Work Request Template

Requested By: (Print Name)	Signature:	Phone : Ext: Mob. :	Area:
Date Requested:	Required Completion Date:		

LIST AND ATTACH REFERENCE DOCUMENTS (Include all pertinent Drawings, FCDs, DCNs, etc. indicate Revision No.)	Latest Revision Verified by: (Initials)	REMARKS

LOCATION AND DESCRIPTION OF FIELD WORK REQUESTED:

Office Work Requested:	Plot: ☐ YES ☐ NO	Scale:	No. of Copies:

FOR SURVEY OFFICE USE ONLY		
Party Chief:	Tech(s):	Ref SWR (s):
Field Priority: ☐ A ☐ B ☐ C	Start Date:	Completion Date:
Office Priority: ☐ A ☐ B ☐ C	Start Date:	Completion Date:
Inst. Data File:	CAD File:	Field Book No. Page(s):
Office File(s):		Checked by: Date:

RECEIVED BY:

(Print Name / Signature) (Date)