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First Kelly-Rig Casing-While-Drilling Field Trial: Overcoming Surface-Hole Losses in Egypt's Western Desert

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Abstract
Surface-hole drilling in Egypt's Western Desert frequently encounters severe lost circulation, wellbore instability in weak shallow formations, and stuck-pipe events, which have caused three well abandonments within two years in the Field X alone. This paper presents the first field implementation of non-retrievable Casing-While-Drilling (CWD) in the region, deployed on a conventional Kelly-drive rig — a configuration seldom documented in published CWD literature. Prior to execution, a comprehensive engineering programme was undertaken comprising torque–drag modelling, hydraulics and ECD simulation, buckling analysis, and a structured risk-mitigation plan. During the trial, a 9⅝″ casing string was used to drill the surface section from 294 ft to a casing point at 2,700 ft (Apollonia Formation). Field results demonstrate a 40% reduction in surface-hole drilling time compared to offset wells and zero losses in unconsolidated sands, with final hole inclination of only 0.45° and 11.64 ft horizontal displacement — the lowest deviation among all offset wells. Crew connection time improved from 2 hours per joint initially to 20 minutes as the operation progressed. The trial also identified practical challenges — drillable shoe failure, bit balling, and fluid-supply logistics during complete losses — yielding actionable lessons for future deployments. The study's novelty resides in demonstrating CWD viability on a Kelly rig without a top drive, providing a detailed engineering-to-execution framework, and quantifying performance gains in a notoriously problematic geological setting.

Keywords: Casing-while-drilling (CWD); lost circulation; Western Desert (Egypt); surface section drilling; wellbore stability; plastering effect; torque and drag analysis; Kelly rig operations; non-productive time (NPT)

Introduction

Drilling surface-hole sections in Egypt's Western Desert is notoriously difficult. The shallow stratigraphy comprises highly porous, fractured formations ranging from shallow uncemented sands to deeper unconsolidated carbonates, which routinely cause severe lost circulation, wellbore instability in the Dabaa shale (leading to stuck pipe during tripping or casing runs), bit balling, reduced rate of penetration, and hole deviation from verticality.

In Field X, three wells were abandoned before reaching surface casing point within two years, imposing costs for new cellar preparation, rig relocation, and lost investment in failed wells. Conventional drilling in this area suffers from extended open-hole exposure leading to instability, lost circulation in fractured/unconsolidated formations, and stuck pipe incidents during tripping or casing runs. These challenges demanded an alternative approach.

Casing-While-Drilling (CWD) replaces conventional drill strings with casing strings to simultaneously drill and case a wellbore, cementing the casing in place without tripping. This approach minimizes risks inherent to separate drilling and casing operations and significantly reduces NPT by eliminating tripping, wiper trips, and casing-running delays[1] CWD has proven effective in such environments through several mechanisms:

- Mitigating lost circulation through enhanced plastering effects [2, 3]
- Improving wellbore stability via better mud-cake formation [4, 5]
- Reducing formation damage [6] and increasing ROP [7]
- Minimizing NPT during surface section drilling [8, 9, 10]
- Enhancing shallow gas kick management while drilling surface sections [11]

The Field X wells are relatively shallow (6,500–8,500 ft total depth) and do not require a drilling rig larger than 1,200 HP. Previously, it was assumed that a Top Drive System would be required for CWD. However, a review of CWD literature revealed cases of CWD utilizing Kelly rigs in Gabon [12], providing the basis for adapting this technique to the available rig fleet.

This work evaluates the first documented CWD field implementation in Egypt's Western Desert and marks the first Kelly-drive CWD well in the Middle East. Elsewhere in the region, non-retrievable CWD has reduced surface-hole losses and rig time in ADNOC Onshore [13] and has been used to drill surface sections exposed to losses and shallow gas [11], while level-1 CWD has secured unconsolidated and unstable formations across extended open-hole intervals [14]. The study integrates a rigorous pre-drill engineering analysis framework with field performance data to assess whether CWD can mitigate the persistent surface-hole problems in this geological context, and to derive lessons for broader application.

Despite the growing body of CWD case histories, three gaps motivate this study. First, the great majority of documented CWD operations rely on a top-drive rig, and the feasibility of non-retrievable CWD on a conventional Kelly-drive rig has rarely been reported. Second, published CWD applications in Egypt's Western Desert are scarce, leaving operators without a region-specific engineering and execution reference for its uniquely loss-prone shallow stratigraphy. Third, few studies couple a complete pre-drill engineering programme (torque and drag, hydraulics and ECD, buckling, and vibration analysis) with quantified field outcomes for a single surface-hole trial.

The principal contributions of this work are threefold: **(1)** the first documented field implementation of non-retrievable CWD in Egypt's Western Desert, and the first Kelly-drive CWD well in the Middle East; **(2)** a transferable engineering-to-execution framework, including a torque-ring upgrade that raised the 9-5/8-in. BTC connection capacity to a level adequate for rotary drilling; and **(3)** a quantified performance comparison against eleven offset wells, demonstrating a 40% reduction in surface-hole drilling time, zero losses in unconsolidated sands, and the lowest recorded hole deviation in the field.

Theoretical Background: The Plastering Effect and CWD Mechanisms

Plastering Effect

The plastering effect (Figure 1 & Figure 2) is a critical mechanism in CWD that enhances wellbore integrity through three principal pathways:

1. Preventing lost circulation through pore-throat sealing

2. Mitigating formation damage by minimizing fluid invasion

3. Strengthening the wellbore to improve pressure containment

The mechanism operates as follows. As the casing rotates, it mechanically smears drilled cuttings and optimally sized particles against the wellbore wall, sealing fractures and pore spaces to form an impermeable barrier Figure 3. This continuous smearing creates a dense, low-porosity filter cake that reduces fluid loss, stabilizes the formation, and minimizes differential sticking risks [15, 16]. By sealing weak zones, the plastering effect widens the mud weight window, allowing safer drilling with higher mud weights when needed — particularly beneficial in fractured or depleted formations where conventional drilling often suffers severe losses. These findings align with observations [1] and [2]who documented enhanced wellbore strengthening in similar CWD applications.



a. plastering effect to restore wellbore hoop stress and plug near wellbore fractures



b. Plastering effect to repair the imperfections of the mud cake and increase near wellbore integrity

Figure 1:-a&b describes two plausible mechanisms of plastering effect to increase wellbore integrity.

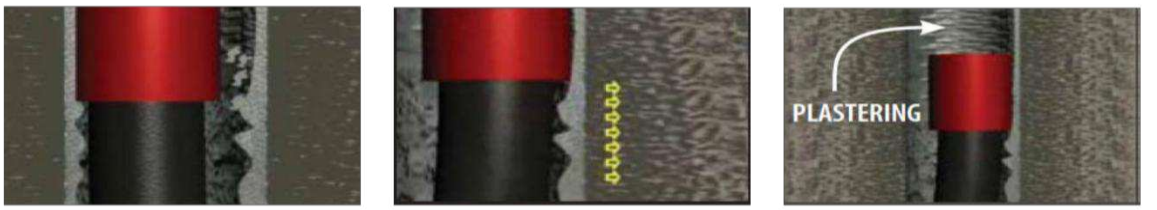

Fig. 1-A: Casing is forced against the bore wall as it advances into the borehole

Fig. 1-B: As mud is smeared into the formation, filter cake builds up on the borehole wall

Fig. 1-C: Filter cake and cuttings are plastered against the borehole wall, sealing porous formations.

Figure 2:-Plastering effect mechanism [2]

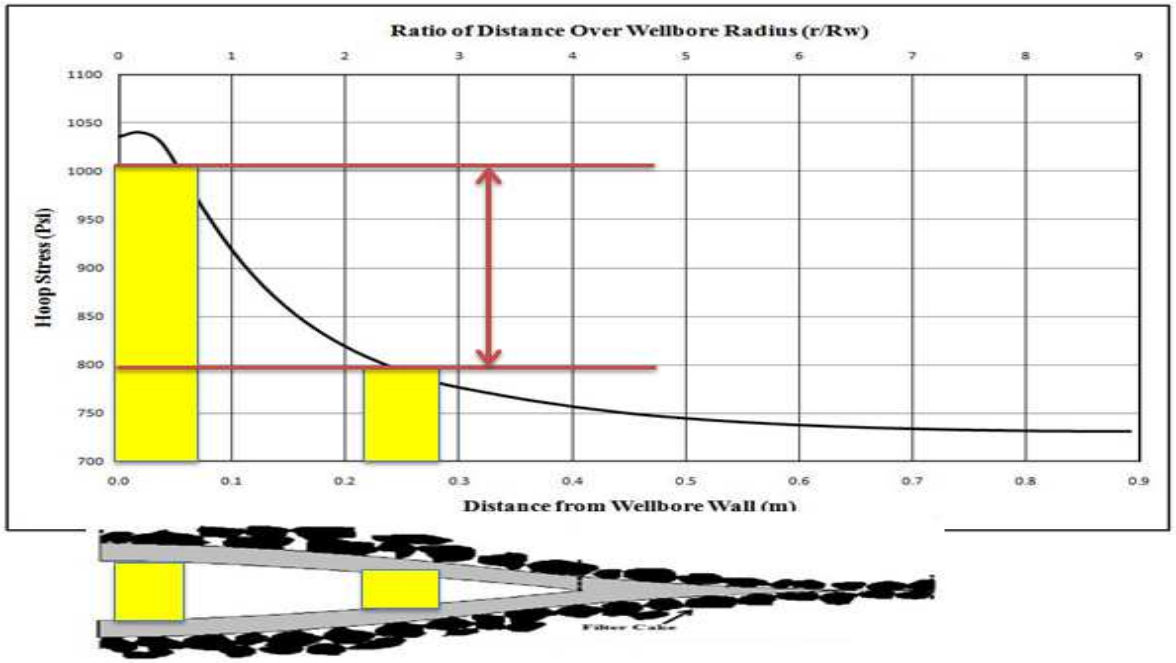

Figure 3:-PSD role in fracture sealing and wellbore hoop stress restoration [15, 16]

Annular Clearance Effects

A key distinction of CWD is the smaller annular clearance between the casing and wellbore compared to conventional drilling Figure 4. The larger outer diameter of casing (vs. drill pipe) creates a tighter annular gap, and during rotation the casing mechanically grinds cuttings into finer particles Figure 5 that are more easily transported upward. These finer cuttings distribution in turn improves the plastering effect, enabling better sealing of fractures and pores.

The high annular velocity (due to restricted flow area) and elevated ECD actively push cuttings toward the wellbore wall, where they are smeared into the formation face, forming a low-permeability filter cake that minimizes fluid loss, strengthens the wellbore, and reduces differential sticking risks.

Vibration and Stability Advantages

The stiffness and larger diameter of the casing string reduce lateral vibrations Figure 6 compared to conventional drill pipe. Eccentric rotation of the casing is more stable, leading to fewer wellbore tortuosity issues, lower mechanical wear on tools and improved weight transfer for ROP optimization. This is particularly relevant for maintaining verticality in unconsolidated Western Desert formations.

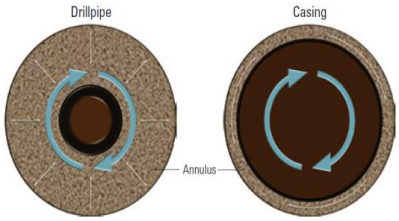



Figure 4:-The annulus is smaller in Casing Drilling in comparison to conventional drilling. [1]

Figure 5:-The difference between CWD cuttings and conventionally drilled cuttings

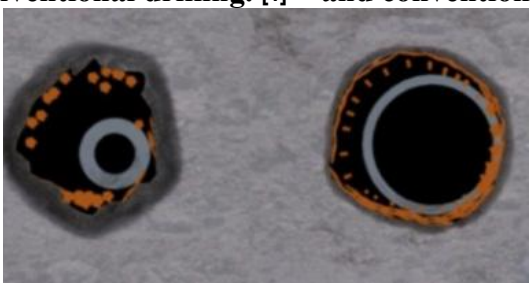

Figure 6:-Wellbore stability improvement by Casing Drilling (right) in comparison to conventional drilling (left). [1]

Additional Advantages of Casing While Drilling (CWD)

Casing While Drilling (CWD) offers numerous operational and technical benefits that enhance drilling efficiency, wellbore quality, and cost-effectiveness. Below is a structured breakdown of these advantages, supported by industry literature and field applications [17]:

- Time and Cost Efficiency: Casing is cemented immediately after reaching target depth, reducing rig time by avoiding wiper trips and hole conditioning[8, 9, 10, 18]. Direct cost savings arise from shorter drilling cycles and reduced NPT.

- Enhanced Wellbore Stability and Hole Quality: The rigidity of the casing improves borehole verticality, reducing tortuosity and dogleg severity. Concentric wellbore geometry mitigates differential sticking risks and promotes better cement bonding when casing is rotated during cementing.
- Improved Hole Cleaning and Pressure Management: Higher annular velocity enhances cuttings transport; elimination of surge/swab effects reduces well control incidents and formation damage from cyclic loading.
- Mitigation of Drilling Hazards: If stuck pipe occurs, casing can be cemented in place, allowing sidetracking with a smaller diameter — no need for fishing. CWD is compatible with Underbalanced Drilling for depleted reservoirs where lost circulation is a major challenge.
- Operational Flexibility: Fewer trips lead to lower risk of dropped objects or pipe handling incidents, and a smaller environmental footprint due to reduced drilling time and fluid usage.

Field Context: Western Desert Surface Hole Challenges

1) Geological and Operational Setting

In Egypt's Western Desert, surface hole drilling poses unique challenges due to highly porous, fractured formations — ranging from shallow uncemented sands to deeper unconsolidated carbonates [19]. The key issues severe lost circulation, Dabaa shale instability causing stuck pipe during tripping or casing runs, bit balling, reduced ROP, and hole deviation have historically resulted in excessive NPT and well failures.

The operator has faced persistent difficulties in drilling surface holes in the Field X, including three well

abandonments before reaching surface casing point in the past two years. These failures carried a heavy cost impact: new cellar preparation, rig move expenses, and lost investment in failed wells. Conventional drilling in this area was further hampered by extended open-hole exposure leading to instability, lost circulation in fractured/unconsolidated formations, and stuck pipe incidents during tripping or casing runs.

2) Offset Well Analysis

A detailed analysis of 11 historical offset wells (designated X-1 through X-11) was performed to identify recurring trouble depths and events. The results are summarized in Table 1.

Table 1: Offset Well Problem Summary (Field X)

Table 1:Offset Well Problem Summary (Field X)

Well	Notes
X-1	Complete loss at 500', 3 cement plugs and blind drilling to 1,500'
X-2	Stuck 9 5/8" 1,500' - cement - run 7" in Apollonia - drill 6"
X-3	Stuck 9 5/8" surf casing - free with diesel & water
X-4	Stuck 9 5/8" surf on jt 49 - free w/ 390 klbs pull
X-5	Stuck 9 5/8 surf casing 2,930' - cement, co and run 7"
X-6	Stuck in surface while drilling cement plug (for complete losses)
X-7	Stuck 9 5/8" at 3,275', pump diesel & cement after few hrs
X-8	9 5/8" casing stop at 600', WT w/ stab.
X-9	Complete. loss on RIH on WT at 2,030', 1-day BR out
X-10	Complete. losses at 1470', drilling blind and stuck at 1484'.
X-11	Complete. losses 1,480', spot LCM, POOH 1,295'-hole collapse

The offset analysis confirms that the **main problems are complete losses, hole collapse, and casing stuck**. These patterns directly informed the CWD design, focusing attention on controlling losses continuously, and minimizing open-hole exposure.

3) Time Distribution Analysis

A time distribution analysis (Figure 7) compared conventional vs. CWD time allocation for Field X wells. Conventional drilling time includes NPT from losses, instability, and stuck pipe, plus additional flat time for tripping out drill pipe and running casing (with associated risk of casing getting stuck due to wellbore deterioration). CWD combines drilling and casing into one operation, eliminating tripping time and separate casing running delays. Based on offset data, potential savings of 30–50% reduction in total section time were projected.

Time Distribution Analysis (Figure 7) compares time allocation for conventional drilling vs. CWD potential in Field X wells:

- Blue Bar (Drilling Time): Represents hours spent drilling surface section to casing point. Including NPT from losses, instability, and stuck pipe.
- Light Red Bar (Casing Running Time): Additional flat time for tripping out drill pipe and running casing, including the high risk of casing stuck due to wellbore deterioration.

- Green Bar (Cementing Time): Standard cement job duration (similar for CWD/conventional).
- Dashed Line (CWD Opportunity): Combines drilling and casing into one operation, eliminating tripping time, separate casing running delays and potential savings: 30–50% reduction in total section time (based on offset data).

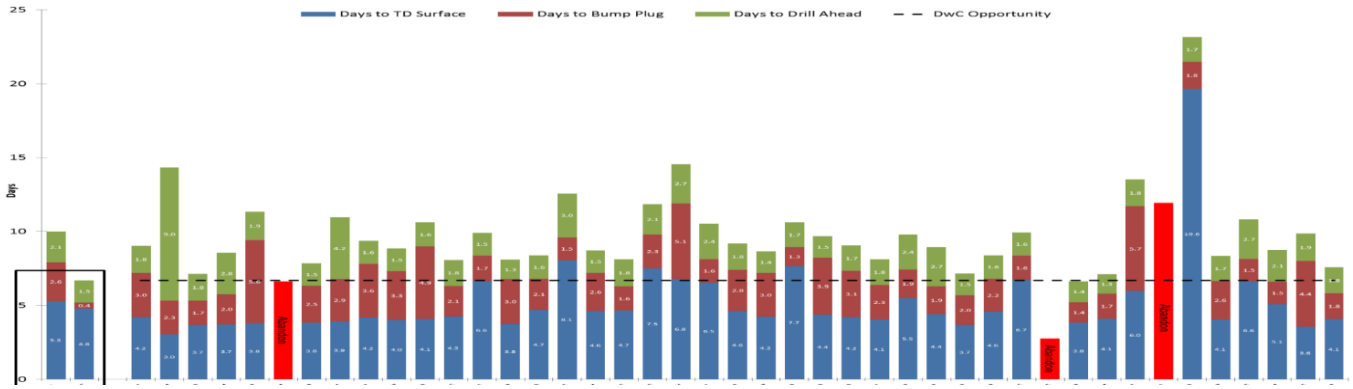

Figure 7:- Surface hole drilling time distribution

Methodology: Engineering Design, Equipment, and Risk Mitigation

1) Planning Phase

Engineering calculations were planned for the trial, including torque and drag analysis, ECD optimization, casing buckling risk analysis, vibration analysis, hydraulics analysis, fatigue assessment, and bit durability analysis. Formation analysis indicated low compressive strength and low formation abrasiveness for the surface hole formations, supporting the selection of a standard PDC-type drillable shoe.

2) Risk Assessment

A comprehensive CWD risk analysis was developed addressing all anticipated hazards. **Table 2** presents the key risks, threats, causes, consequences, and mitigation measures identified prior to execution.

Table 2: CWD Risk Assessment (Field X trial) Casing while drilling challenges and mitigation Risk Analysis

Risk	Causes	Consequences	Mitigation Measures
Late connection time	Crew lack of experience with casing connections	Each connection takes excessive time	Monitor first 10 connections; pre-job safety meeting; ensure good housekeeping
Thread damage	Wrong connections or pull out of hole with casing	Casing thread damage requiring replacement	Monitor first 10 connections; pre-job safety meeting; ensure good housekeeping
Casing torsional failure	High torque exceeding connection limits	High vibrations leading to high torque readings	Monitor connections; pre-job safety meeting; use torque rings
Bit balling	Shale formation; insufficient hole	Decreased rate of penetration	Increase flow rate; jerk string; circulate heavy pills with 15–20 ppb fine nut

	cleaning		plug; use surfactant or shale stabiliser; diesel pills; POOH with casing if necessary
Hole packed off	Borehole instability — shale swelling, carvings	Consider cementing casing in place	Minimise connection time; ensure proper hole cleaning; monitor pump pressure; maintain high-viscosity mud
Differential sticking	Shale instability; thick filter cake; mud quality	Consider cementing casing in place	Rotate casing during connections; detect drag after each connection; add 5% diesel to mud before entering Dabaa; use HV pills loaded with LCM if drag increases; apply shock force or safe over-torque if stuck
Lost circulation	Unconsolidated shallow formations; presence of caverns	Major losses; blind drilling; hole collapse	Monitor ECD and drilling parameters; have LCM and contingency planning in place (sufficient material and water on site)
Float equipment failure (cementing)	Equipment failure; washout; debris in float	Hold pressure during WOC	QC of float equipment before RIH; back-up float shoes available on location
Plug not bumped (cementing)	Plug bypassed or pump miscalibrated	Delay pressure test until after WOC	Agree on maximum over-displacement volumes before operation; review/confirm hard cement pressure test values

Beyond the general risk matrix, three principal field-specific challenges and their mitigations were identified:

- Differential Sticking: The larger contact area of the casing relative to drill collars could increase differential sticking risk if losses are not controlled by the "smear effect." Mitigation included keeping mud weight according to program, minimizing static time in the wellbore, and preparing pipe-lax material or diesel to free differentially stuck pipe.
- Bit Balling or Failure: If the bit becomes dull or balled, a trip is required. A trip to surface to change or clear a bit while using Kelly CWD requires breaking out and laying down casing joints, potentially leading to damaged threads on joints which would need replacement and later repair. Mitigation involves utilizing a conservative bit design to ensure the bit reaches casing point, and in the event of bit balling, pumping drilling detergents with light WOB, high RPM, and high flow rates with the bit off bottom.
- Hole Deviation: Due to soft and unconsolidated formations, the hole may deviate from verticality. The stiffness of the 9⅝″ casing and the close tolerance between casing couplings and the wellbore were expected to help mitigate build tendencies. If angle built during the trial, correction could be applied in the next hole section. For future wells, stabilizers could be added to the casing BHA if necessary.

3) Non-Retrievable CWD Toolbox

The non-retrievable BHA comprised the following components:

- Drillable Shoe: Figure 8 & Figure 9 A PDC-type casing drill shoe attached at the bottom of the casing to enable drilling to the planned casing depth. Drillable shoes have different designs like normal PDC bits, with limitations including bit balling, dynamic stability, and penetration rate[1].
- Float Collar: Placed one to three joints above the drill shoe, providing a seat for cement plugs and incorporating a backpressure valve to prevent U-tube flow of cement back into the casing
- Centralizers: Specifically designed for CWD to prevent wall contact and wear of the casing body or connections, with wear bands hardfaced with tungsten carbide to strengthen the connection with the casing coupling[20].
- High-Torque Rings on Connections





Figure 8 :-Drill shoe after being drilled in lab

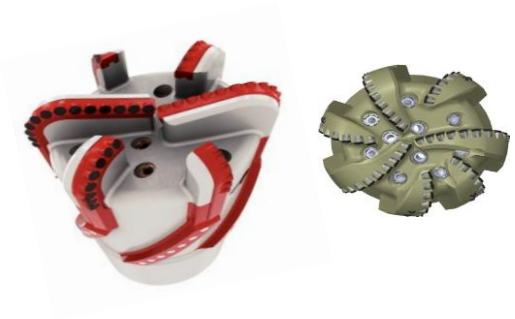

Figure 9:-Drill shoe

4) Casing Connections and Torque Ring Enhancement

The operator typically uses 9⅝″ casing with BTC connection, which has a low inherent torque limit. Table 3shows the standard API BTC torque capacity for 9⅝″ casing.

Table 3:API Casing Buttress Thread Data for 9⅝" Casing (Without Torque Rings)

Weight (ppf)	Grades Available	Wall (in)	ID (in)	Approx. Torque Delta — No Rings (ft-lb)
43.5	M-65, L-80, N-80, C-90, T-95, P-110	0.435	8.755	9,630

Without torque rings Figure 10 & Figure 11, the maximum torque delta is only 9,630 ft-lb, which is insufficient for drilling operations. Torque rings were therefore installed to increase the torque rating of the BTC connection by creating a shoulder-to-shoulder connection. Table 4 shows enhanced connection performance with torque rings for 9⅝″ (9.625″) OD, 36.00 lb/ft BTC K55 casing.

Table 4:9⅝" (9.625") OD, 36.00 lb/ft BTC K55 — Performance with Torque Rings

Torque	Compression	Bending	Tension

Using MIN PFW Pin Face Width 75%	Min.	Opt.	Max.	Maximum	Max. Bend Radius	Max. Rec. Setting Depth	
	Ft-lb	Ft-lb	Ft-lb	Lb	°/100’		
Est Make-Up Torque	8,500	9,500	10,500	324,400	20°	Feet	S.F.
Delta Torque	3,450	10,800	18,000			13,000	1.6
Total Torque	11,950	20,300	28,500				

Additional design limits: Maximum Compression = 324,400 lb; Maximum Bend Radius = 20°/100 ft; Maximum Recommended Setting Depth = 13,000 ft with Safety Factor 1.6.

The data clearly demonstrates that torque rings have a significant effect on the total torque capacity of the BTC connection for casing-while-drilling applications.



Figure 10:-Torque Ring

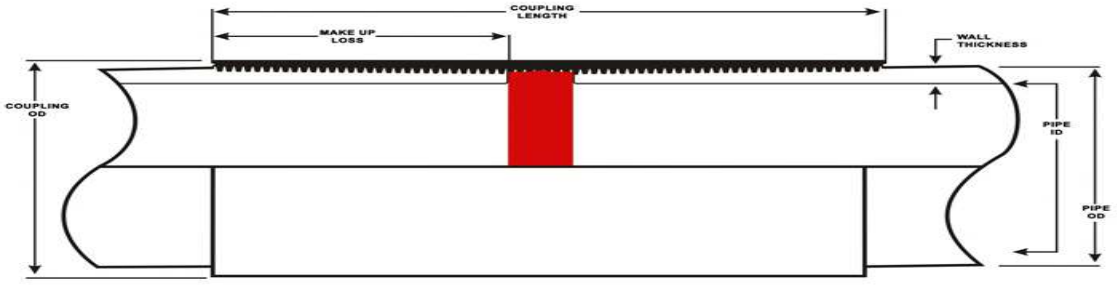

Figure 11:- Torque Ring

5) Casing drive systems

The hoisting system of the rig must hold the weight, apply rotational torque and contain pressure. So, it is required to have a system connected to the top drive or Kelly to rotate the casing string and transfer all their functions to the casing. The casing drive system (CDS) connects the casing string to a top drive without screwing into the casing coupling through a slip assembly. In addition to the slip assembly it has

a packer which provides seal for drilling fluid inside the casing string [21]. The use of casing drive system is reliable, fast operation, reduce manpower and help in avoiding damage to the casing threads. Where casing must be advanced through tight or problematic open hole, complementary drillable casing-deployment tools such as motorized reamer shoes have been run successfully in regional wells [22].

6) Rig Modifications

The trial rig was a 1,200 HP mechanical rig equipped with a Kelly drive. The following modifications were required to adapt it for CWD:

1. Mousehole modification: Extended to 36 ft total length and plugged from the bottom cone.
2. Standpipe manifold: Increased in length by 13 ft Figure 13
3. Kelly hose: Increased to 75 ft to accommodate the length of 9⅝″ casing joints plus Kelly during connections Figure 13



Figure 12:-Rig Tong



Figure 13:-Stand Pipe

7) Casing Preparation

A total of 115 joints of 9⅝″ casing (36 ppf, BTC) were cut to 34 ft length as required for Kelly travel length to match the height of the derrick. The BHA was assembled before the job in the yard and thread locked. Special handling procedures were developed, as this was the first time CWD was being performed with a Kelly rig in the Middle East

Pre-Job Engineering Analysis Results

1) Formation Analysis:

Figure 14 Shows low compressive strength and low formation abrasiveness for surface hole formations.

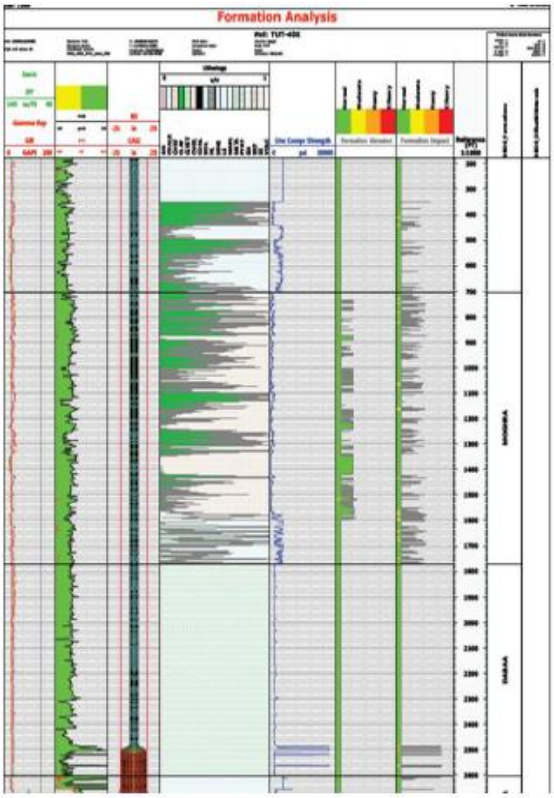

Figure 14:Formation Analysis

2) Torque and Drag Analysis

Torque and drag are induced by frictional forces acting between the borehole and the casing string. In many situations, drilling with casing in directional wells increases normal force beyond conventional drilling due to the weight of the casing, larger diameter, and casing stiffness; directional CWD has likewise been used to land surface casing on the planned trajectory in a single operation, avoiding a contingency string [23][21, 24]. For the vertical well T-1, simulation results indicated that:

- String torsional limits are not exceeded
- Helical and sinusoidal buckling failures are not expected
- Tensile limits are not expected to be exceeded

These results (Figure 15, Figure 16 & Figure 17) confirmed that the 9⅝″ casing could be rotated safely to section TD without exceeding connection capacity (especially with the enhanced torque ring values in Table 4), and that the vertical well geometry precluded buckling under the planned weight-on-bit.

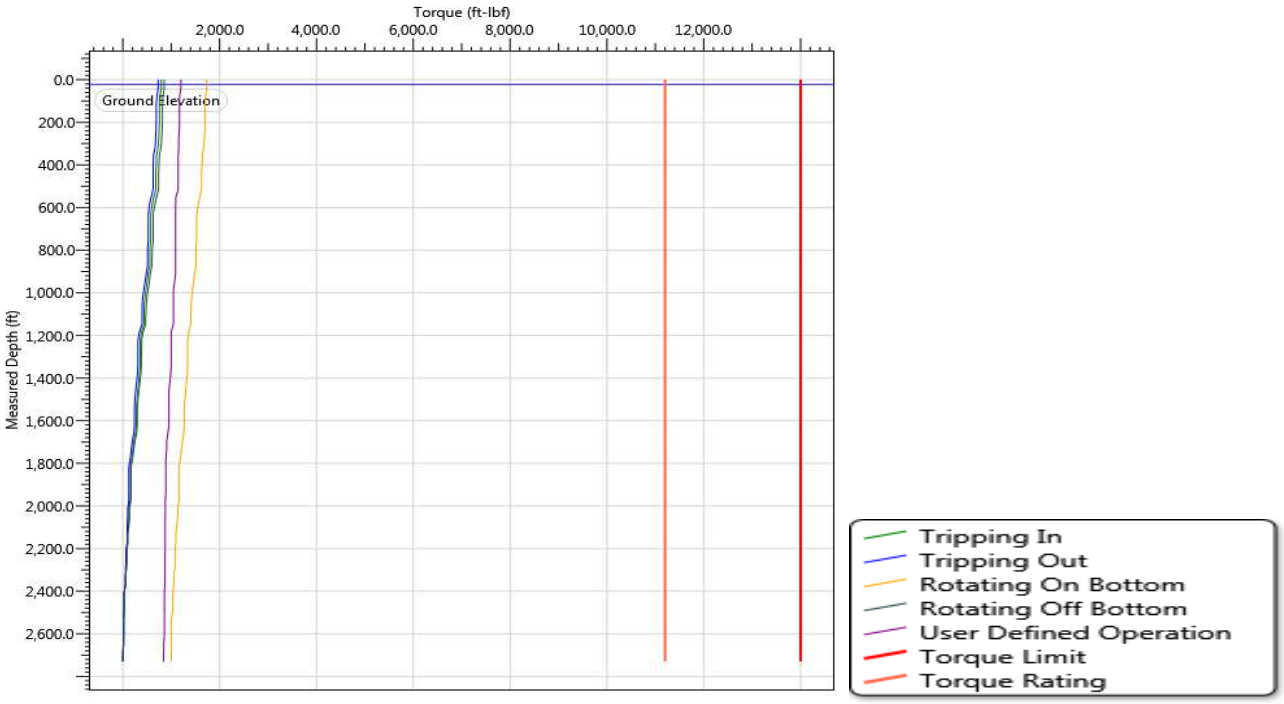

Figure 15:- Torque Analysis of well T-1

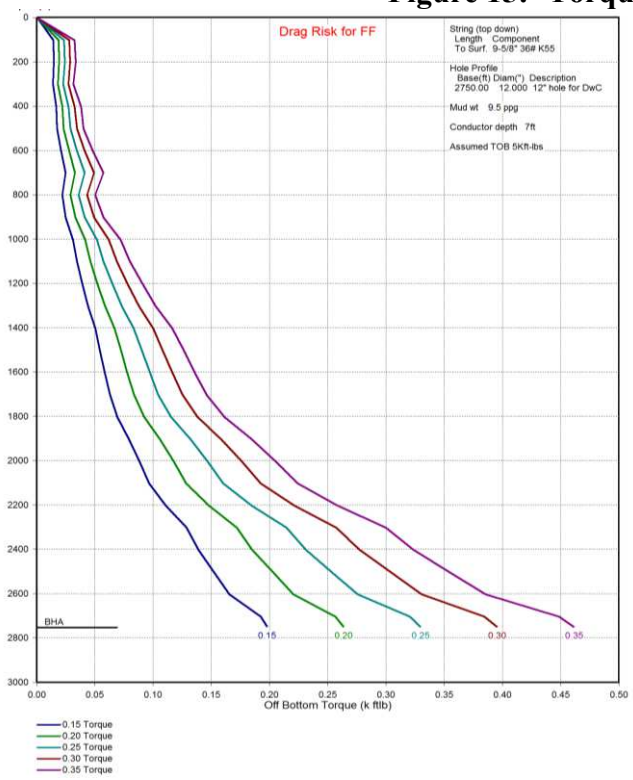

Figure 16:- Drag Analysis of well T-1

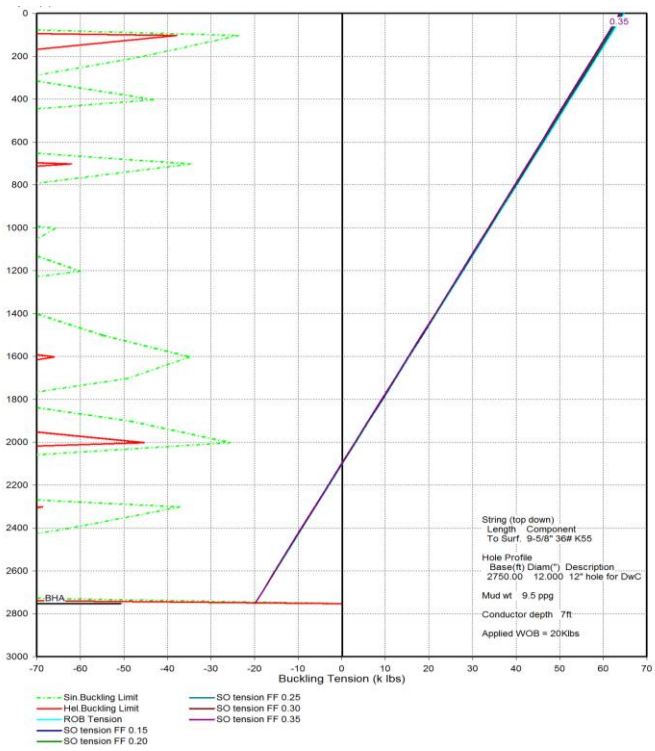

Figure 17:-Buckling Analysis of well T-1

3) Vibration Analysis

BHA vibration is influenced by applied drilling parameters. Simulation was conducted at various assumed running parameters to determine safe and optimal operating ranges prior to running the job. If excessive lateral vibration were experienced during operation, drilling parameters could be adjusted

within an optimal operating range (identified as the "green zone" in the simulation output). The inherent stiffness of the 9⅝″ casing was expected to limit lateral vibration significantly compared to conventional drill pipe.

4) Hydraulics Analysis

Hydraulic simulations for both well sections indicated that:

- Pressure drop across drill string components is normal
- Expected annular velocities are sufficient to provide good hole cleaning
- Required flow rates to clean the hole sections are achievable with the recommended flow rates
- Recommended flow rates are expected to induce circulation pressures and ECDs at TD that do not exceed assumed formation fracture pressure gradients

The ECD and cuttings concentration analysis (Figure 18) confirmed that the proposed flow rate of 520 gpm would maintain adequate hole cleaning without fracturing the formation.

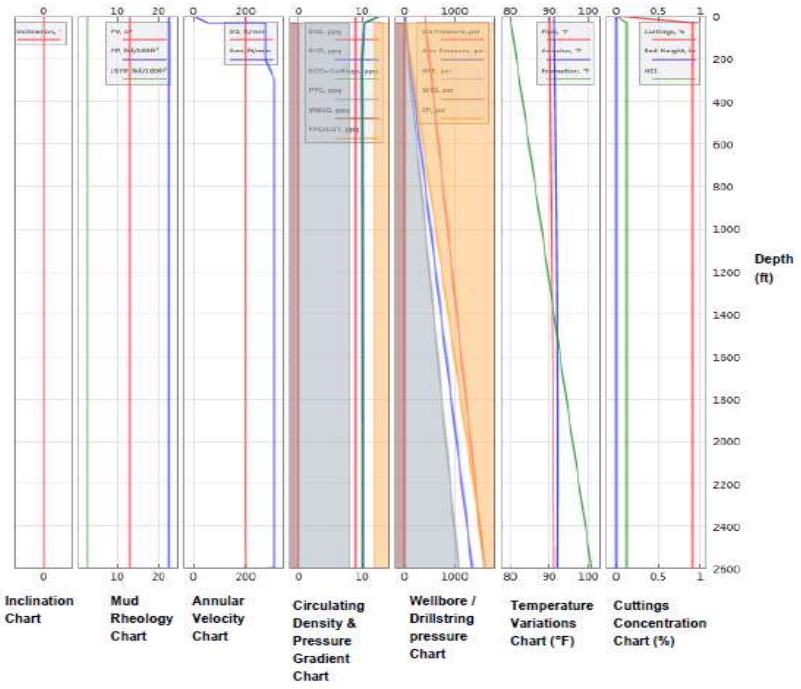

Figure 18:ECD and cuttings concentration graph

Field Execution and Results

1) Execution Summary

Well T-1 served as the rig evaluation trial for Kelly CWD. The CWD operation commenced at 294 ft MD, after drilling a minimum of 300 ft using conventional methods. The objective was to drill a 12″ hole with CWD Figure 19 to the casing point at 2,700 ft (Apollonia Formation) with the proposed parameters and minimal losses compared to offsets.

Table 5:Actual Drilling Parameters — Well T-1

Parameter	Value
Flow Rate (GPM)	520
Pump Pressure (PSI)	600

Weight on Bit (klb)	8–10
Rotary Speed (RPM)	100
Torque (ft-lb)	900–2,000
Rate of Penetration (ft/hr)	55

All measured drilling parameters aligned with pre-job engineering simulations. Notably, the measured torque range of 900–2,000 ft-lb remained well below both the enhanced connection capacity (optimum total torque = 20,300 ft-lb per Table 4) and the torsional limits predicted by the torque and drag model. This confirmed the adequacy of the connection upgrade and the validity of pre-job engineering

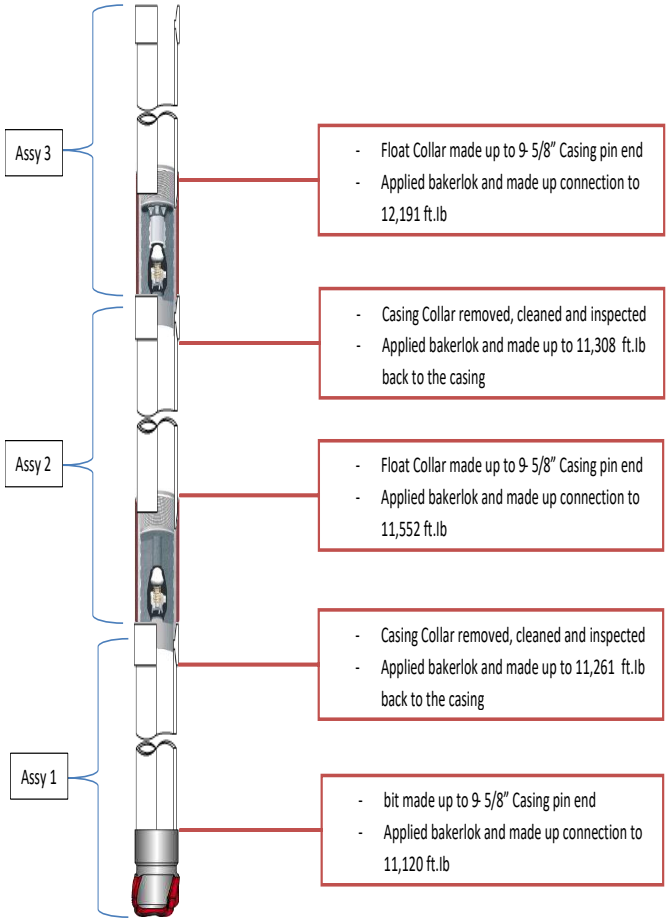

Figure 19:-Drilling with casing Bottom Hole Assembly

2) Connection Time Learning Curve

Crew performance for casing connections improved markedly during the operation. Connection time started at approximately 2 hours for the first casing joint and progressively reduced to 20 minutes per joint by the end of the run. This improvement represents a direct outcome of the pre-job training programme and the monitoring of the first 10 connections as specified in the risk mitigation plan. Progression is a strong example of a rig evaluation study, demonstrating that crews can achieve acceptable CWD connection efficiency on a Kelly rig with practice.

3) Cementing and Drill-Out

The cement job was performed successfully. The shoe track and drillable shoe were subsequently drilled out using a PDC bit without any problems. A Formation Integrity Test (FIT) was performed to verify the integrity of the cemented surface casing.

4) Wellbore Trajectory

A gyro survey was run after setting the casing to determine hole deviation. The results showed an inclination of only 0.45° with 11.64 ft horizontal displacement — the lowest survey among all offset wells in the area. This confirms the hypothesis that the stiffness of the 9⅝″ casing and the close tolerance between casing couplings and the wellbore effectively mitigated build tendencies in these soft, unconsolidated formations.

A comparison of gyro survey data between the CWD well T-1 and the offset well T-01 (Figure 20) visually demonstrates the superior trajectory control achieved with casing drilling. The T-1 wellpath remained consistently closer to vertical than the offset, particularly through the deeper formations where conventional wells typically accumulated deviation.

AVERAGE READING	T-1
GPM	520
PUMP PRESSURE (PSI)	600
WOB (KLB)	8-10
RPM	100
TORQUE (LB. FT)	900-2000
ROP (FT/HR)	55

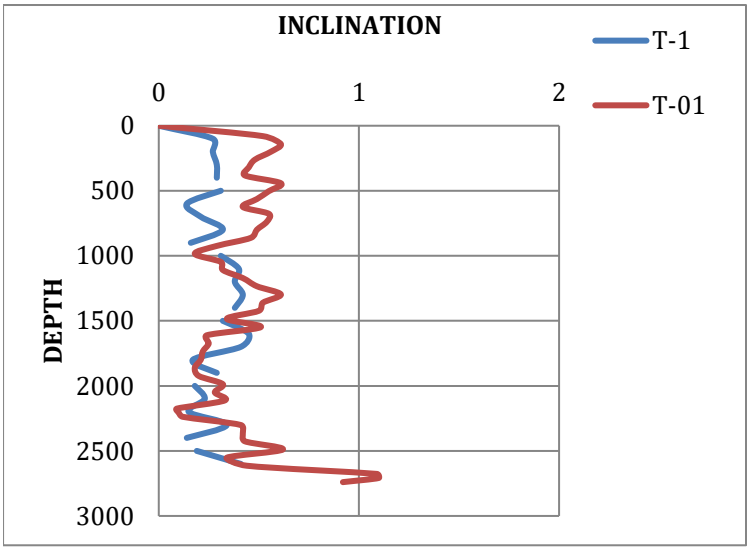

Figure 20:- Gyro survey data comparison between well T-1 and offset well T-0

Operational Challenges Encountered

Despite the overall success, the trial encountered three notable challenges that yielded important lessons:

- Challenge 1 — Complete Losses Without Water Availability: The well experienced complete losses during a portion of the run, but drill water was not available in sufficient quantity to continue blind drilling. The operation was suspended, the string was pulled out of hole, and the team waited until adequate water was collected before running in hole again with conventional drilling.

  Recommendation: Ensure enough water is available on location before spud. For future CWD operations in loss-prone areas, water supply logistics must be treated as a critical-path item.

- Challenge 2 — Drillable Shoe Failure: Reaming was required when running in hole with conventional drilling after the CWD phase, because the drillable shoe had failed . The 12″ drillable shoe was undersized relative to the conventional BHA gauge, requiring additional reaming time.

  Recommendation: Use a 12.25″ drillable shoe instead of 12″ to eliminate the reaming requirement when transitioning to conventional drilling.

- Challenge 3 — Bit Balling and Slow ROP: Bit balling occurred in shale formations, causing slow rate of penetration and necessitating a pull out of hole to clean the bit.

  Recommendation: Pump drilling detergents and nut plug sweeps; use light WOB, high RPM, and high flow rates with the bit off bottom; check bit hydraulics to achieve maximum HSI.

- Additional Issue — Drill-Out Coring: After drilling the drillable shoe with a steel bit, the bit was found to have cored (i.e., left an uncut centre).

  Recommendation: A clean-out trip should be considered using a standard MT bit to drill the shoe, and the recommended drill-out procedure from the drilling shoe supplier should be followed.

Key Performance Outcomes

The field trial Figure 21 yielded the following headline results:

- 40% reduction in surface-hole drilling time compared to conventional offset wells
- Zero losses in unconsolidated sands — a remarkable improvement given that all offsets experienced severe or total losses in these intervals
- Lowest hole deviation (0.45°) among all offset wells in the area
- Successful cementing and drill-out without complications
- Zero safety incidents during the CWD operation

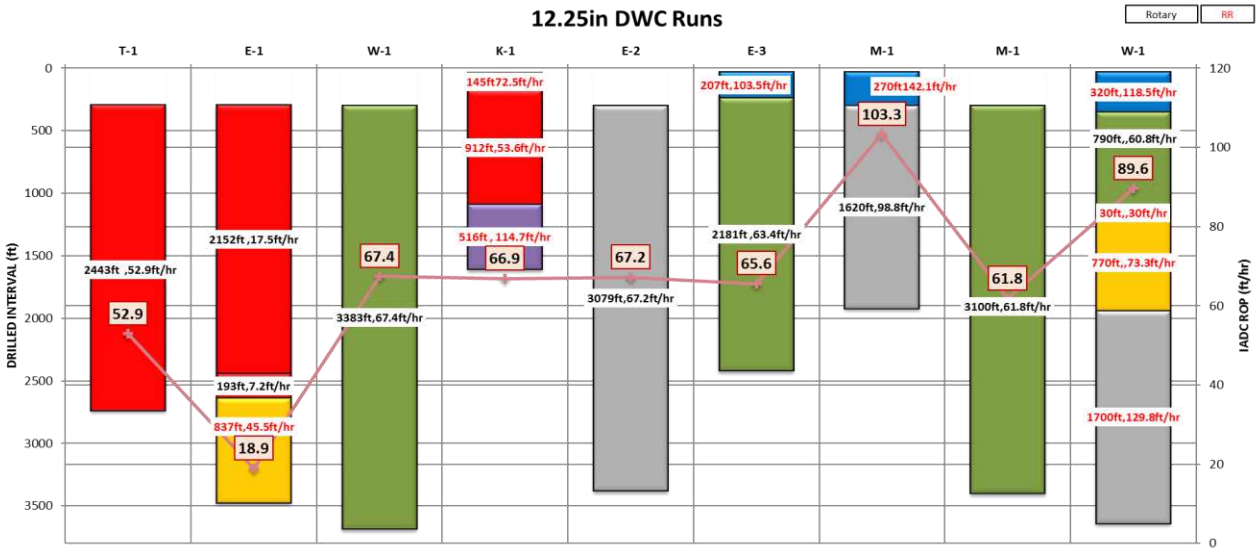

Figure 21:CWD run summary

Discussion

Plastering mechanism. The elimination of losses in intervals where every offset well had suffered severe or total returns provides direct field evidence of the plastering effect. As the 9-5/8-in. casing rotated within the narrow annulus, drilled cuttings and mud solids were smeared into the porous, fractured surface formations, sealing pore throats and micro-fractures and widening the operating mud-weight window. This is consistent with the qualitative and experimental findings of Karimi et al. [2] and Salehi et al. [15], and with the ADNOC Onshore field results of Bethancourt et al. [13], in which medium losses were cured by the same wellbore-strengthening mechanism.

Trajectory control. The 0.45-degree final inclination, the lowest among all offset wells, supports the hypothesis that the bending stiffness of the casing string and the close coupling-to-borehole tolerance suppress build tendencies in soft, unconsolidated formations. This complements directional-CWD experience elsewhere, where casing stiffness was managed to land surface casing on plan [23].

Performance and non-productive time. The 40% reduction in surface-hole time arises chiefly from combining drilling and casing into a single operation, eliminating drill-pipe tripping, wiper trips, and the high-risk casing run that repeatedly caused stuck-casing events in the offsets (Table 1). The connection learning curve, from approximately 2 hours to 20 minutes per joint, indicates that the time penalty of Kelly-rig CWD is transient and crew-experience driven rather than intrinsic. [Author to insert: total section hours for Well T-1 versus the offset average, and the corresponding NPT reduction, to quantify this comparison.]

Generalizability and economics. Because the trial rig was a 1,200-hp mechanical Kelly rig, the results broaden the applicability of CWD to asset fleets that lack top-drive capability, lowering the barrier to adoption in mature onshore basins. Given that three Field X wells were abandoned before surface casing point within two years, the avoided-abandonment value alone is material. [Author to insert: estimated cost of a single abandonment (cellar preparation, rig move, and lost investment) to frame the economic case in USD.]

Limitations

This study reports a single-well field trial; although it is benchmarked against eleven offset wells, statistical generalization is limited and confirmation across additional wells is recommended. The engineering analyses were validated against surface field observations rather than independent downhole measurement (no downhole vibration or annular-pressure-while-drilling data were acquired). A fully continuous CWD run to total depth was also constrained by the drillable-shoe failure, bit balling, and the water-supply interruption during complete losses. These limitations bound the conclusions and motivate the recommendations that follow.

Conclusions

This case study establishes that Casing-While-Drilling is a viable and highly effective method for overcoming surface hole challenges in Egypt's Western Desert. The principal conclusions are:

1. The first Kelly-drive CWD well in the Middle East was executed successfully in the Western Desert, proving that CWD can be deployed on rigs without top drives given appropriate tooling (casing drive system, torque rings) and planning.
2. Surface-hole drilling time was reduced by 40% compared to conventional offset wells, primarily through the elimination of separate tripping and casing operations and the avoidance of the severe NPT that historically plagued this area.
3. Zero losses in unconsolidated sands confirmed the plastering effect's efficacy in sealing fractures and pore spaces in real time — a transformative result in a field where every offset well experienced severe or total returns losses.
4. Wellbore verticality was the best recorded in the field (0.45° inclination, 11.64 ft horizontal displacement at ~2,700 ft), demonstrating the stiffness advantage of the casing string for trajectory control in soft formations.
5. Pre-job engineering analyses (torque/drag, hydraulics, vibration, buckling) were validated by field observations, confirming the reliability of standard modelling approaches for CWD planning. Torque ring upgrades were essential, raising BTC connection capacity from ~9,630 ft-lb to an optimum total of 20,300 ft-lb.
6. CWD works on both Kelly and top-drive rigs, broadening its applicability across the operator's and similar operators' asset portfolios
7. Practical challenges encountered — drillable shoe durability, water supply logistics during complete losses, and bit balling — are manageable with improved planning (pre-positioning water supply, using 12.25″ shoes, and employing anti-balling sweeps) and do not diminish the overall viability of the technique.
8. In areas without shallow gas, CWD requires no specialised tools — only a casing drive sub for effective rotation — making it ideal for mitigating losses.

Nomenclature

BHA = bottomhole assembly; BTC = buttress thread coupling; CDS = casing drive system; CWD = casing while drilling; ECD = equivalent circulating density; FIT = formation integrity test; HSI = hydraulic horsepower per square inch; ID = inner diameter; LCM = lost-circulation material; MD = measured depth; NPT = non-productive time; OD = outer diameter; PDC = polycrystalline diamond

compact; ppf = pounds per foot; ROP = rate of penetration; RPM = revolutions per minute; TD = total depth; TVD = true vertical depth; WOB = weight on bit; WOC = waiting on cement.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request. Certain operational data are subject to confidentiality restrictions imposed by the operator.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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SI Metric Conversion Factors

ft x 3.048* E-01 = m; in. x 2.54* E+00 = cm; bbl x 1.589 873 E-01 = m3; lbf x 4.448 222 E+00 = N; psi x 6.894 757 E+00 = kPa; degree x 1.745 329 E-02 = rad. (*Conversion factor is exact.)

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