Stress Analysis of Buried Pipeline Using Finite Element Method

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Abstract

This study aims to analyze the behavior of underground part of steel pipelines under the effect of loads caused by internal pressure and temperature variation due to transportation of hydrocarbon products. The pipeline assumed to be buried in a sandy soil. The finite element method is used to carry out this analysis using ANSYS 12.0 program. Four parameters are studied including length of the buried part of the pipeline, soil properties, depth of soil cover, and ends condition of the buried part of the pipeline. It is found that increasing the length of the buried part of the pipeline or increasing values of the normal and tangential modulus of subgrade reactions for the surrounding soil causes decreasing in the values of longitudinal displacement, stress, and strain. Soil cover depth over buried pipeline has no effect on the longitudinal displacement, but the stresses and strain increased when the soil cover depth increases. From studying the effect of boundary conditions of the two ends of steel buried pipeline, it is found that longitudinal maximum displacement did not affected, but the longitudinal stresses and strains increase with small rate values.

Keywords: Buried pipeline analysis, Finite element analysis, Nonlinear analysis, Soil pipe interaction.

1. Introduction

As pipelines, over or underground, are the means by which hydrocarbon products are conveyed between plant items, sometimes, these pipelines are subjected to temperature variation, pressure and flow or combination of these phenomena that may cause movements in the pipeline. There are some requirements must be considered in the design of any pipe system; and can be summarized as [1]:

1- The pipe must carry the requisite amount of hydrocarbon products with an acceptable pressure drop between the various terminals.

2- Have sufficient inherent flexibility so that under all specified operating conditions, the forces and moments imposed onto adjoining plant and the internal stress in the pipe material will all be within acceptable limits.

3- Have an adequate service life.

4- Be economic in initial and subsequent cost.

If a piping system is subjected to a change in temperature, the system will be affected due to thermal expansion and will be placed in a condition of stress due to the restraining effects of the plant at the pipe terminal points. It follows that the pipe system will thus exert reactions on the plant terminal points. In addition, stresses and reactions will be generated due to weight of the pipe, the fluid flowing in the pipe, and the lagging around the pipe.

Determining of pipeline stresses for the design of petrochemical and power plant piping systems involves many complex mathematical calculations. These calculations can be solved using several computer programs. These programs need data that include physical properties, allowable stresses, dimensions, stress intensification factors and thermal expansion coefficients.

Since the pipelines are safe and economical means of transporting gas, water, sewage and other fluids, they are usually buried in the ground to provide protection and support. The construction techniques of the pipelines involve either conventional trenching and backfilling, or trenchless methods such as micro tunneling.

Pipelines are generally designed on the basis of the flow requirements and the operating pressure. For buried pipelines, additional design requirements are needed such as the maximum and minimum cover depth, the trench geometry and backfill properties [2].

Buried pipe is a structure for conveying fluid. Stress analysis of underground pipeline is quite different from that aboveground pipeline. Various factors such as soil to pipe interaction, dead and live loads of soil, anchorage force and so on, must be considered [3].

The objective of this paper is to analyze the underground steel pipelines under the effect of loads caused by internal pressure and temperature variation due to transportation of hydrocarbon products and external load from soil cover and their effect on the required length to resist the longitudinal movement of the pipe. Soil properties, and the case of ends condition of the buried part of the pipeline and their effect on the longitudinal displacement and stresses that induced in the buried part were also studied. The steel pipe is assumed to be buried in a sandy soil. Finite element method is to be used to analyze the displacement, stresses and strain in the buried pipeline. Modeling of the problem is to be conducted by using ANSYS 12.0 program.

2. Review of Literature

Stress Analysis of Underground Pipelines

Earliest studies concerning with the stresses and deflections occurred in pipelines at the transition from fully restrained to unrestrained condition was done by Schnackenberg [4]. Analysis of stresses and deflections in transition areas, resulting from internal pressure and temperature change, is necessary in determining anchor block requirements and design. Longitudinal deflections were used to determine whether an anchor block is required.

Peng L. [5] explained that in fully restrained pipelines either by soil friction or mechanical anchors, longitudinal stress was found to become compressive for a moderate temperature change of about 36°C for 358 MPa Specified minimum yield strength (SMYS) of pipe. If longitudinal stress is compressive, it should be added absolutely to hoop pressure stress to obtain equivalent tensile stress. This equivalent tensile stress, rather than longitudinal stress, was limited to 0.9 SMYS. For a temperature rise of about 72°C, equivalent tensile stress started to govern pipe wall thickness. Pipe thickness determined by pressure alone was found not to be sufficient. Although internal pressure reduced longitudinal compressive stress at the fully restrained section of the line, it also increased expansion rate at the unrestrained portion. This pressure elongation was significant, especially in lines with lower temperature rise such as in gas transmission lines. The anchor force required to anchor the fully restrained pipe was found to be equal to the sum of the force required to resist longitudinal stress at the restrained side plus pressure end force at the unrestrained side as shown in Fig. (1).

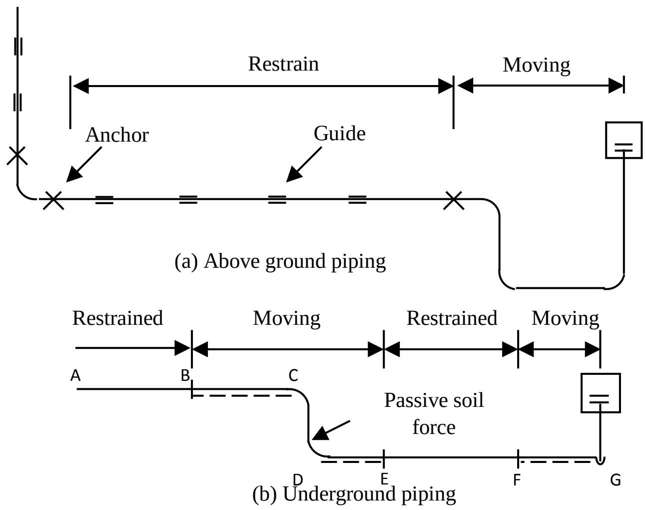

Fig. (1) Restrained and moving portions of a pipeline.

Soil forces that are acting on the pipe were studied by Peng L. [6]. He concluded that for buried pipeline, the pipe wall expands toward the end or a bend, but the central portion of the line will be fully restrained by the soil friction force. Total movement at the free end was inversely proportional to soil friction force but was directly proportional to the square of temperature difference between operating and installation conditions. Because of the lateral soil force, movement at a bend was about one-half of movement at the free end.

Dhuha N. [7] used finite element method to study the effect of the length of buried part of the pipeline, soil properties, depth of soil cover, and ends condition of the buried part. The load that affected on the pipeline were caused from internal pressure and temperature variation. She found that increasing the length of the buried part of the pipeline causes decreasing in the values of longitudinal displacement, stress, and strain due to increasing the contact surface between the buried part of the pipe and the surrounding. It is concluded that increasing values of the modulus of subgrade reactions for the surrounding soil, causes decreasing in the longitudinal displacement, stresses and strain. It was found that the stresses and strain increased due to increasing the soil cover depth over the buried part, while there is no appreciable effect on the values of the longitudinal displacements. Also the longitudinal maximum displacement did not affected by fixing the two ends of the buried part of the pipeline, but the longitudinal stresses and strains increased with small rate values.

3. Stress Analysis of the Pipelines

The stress analysis of the pipelines involves special problems, such as unique characteristics of a pipeline, code requirements and techniques. Elements of analysis include pipe movement, anchorage force, soil friction, lateral soil force and soil-pipe interaction [5] and [6].

Unique Characteristics

Unique characteristics of a pipeline include [8]:

1- High allowable stress: A pipeline has a rather simple shape. It is circular and very often runs several kilometers before making a turn. Therefore, the stresses calculated are all based on simple static equilibrium formulas which are very reliable. Since stresses produced are predictable, allowable stress used is often of high value.

2- High yield strength pipe: Although a pipeline operating beyond yield strength may not create structural integrity problems, it may cause undesirable excessive deformation and possibility of strain follow up. Therefore, high-test line pipe with a very high yield to ultimate strengths ratio is normally used in pipeline construction. Yield strength in some pipes can be as high as (80%) of ultimate strength. All allowable stresses are based only on yield strength.

3- High-pressure elongation: Movement of a pipeline is normally due to expansion of a very long line at low temperature difference. Pressure elongation contributes much of the total movement and must be included in the analysis.

4- Soil-pipe interaction: The main portion of a pipeline is buried underground. Any pipe movement has to overcome soil force, which can be divided into two categories: friction force created from sliding and pressure force resulting from pushing. The major task of pipeline analysis is to investigate soil-pipe interaction.

Code Requirements

Pipelines normally are designed, constructed, inspected and operated according to minimum American standard [9] and British safety standards [10].

The code ANSI B31.4 does not have a special allowance for longitudinal stress [5]. It requires, however, that combined equivalent stress shall not exceed 90% of (SMYS).

Thermal Expansion Loads and Stresses

The axial stress and anchor reactions in buried pipe subject to temperature differential may be conservatively estimated by assuming that the pipe is sufficiently long for the pipe/soil friction to fully restrain the pipe. In this case, the buried pipe is described as (fully restrained). The maximum compressive thermal stress in a fully restrained pipe is calculated by [11]:

$$S = E\alpha (T_2 - T_1) - \nu S_h \qquad (1)$$

where:

S = Compressive longitudinal stress due to temperature differential, kN/m^2.
E = Modulus of elasticity of steel; kN/m^2.
α = Coefficient of thermal expansion, $^{o}C^{-1}$.
T_2= Maximum operating temperature, ^{o}C.
T_1= Installation temperature, ^{o}C.
ν = *Poisson's ratio for steel*

S_h = Hoop stress due to internal pressure, kN/m^2.

The axial load “Fa” in the pipe or the axial load at an anchor due to this temperature differential is:

$$F_a = S \,.\, A_m \qquad (2)$$

where;

A_m = Metal cross section of pipe, m^2.

To find the length “L” over which the transition occurs [6]:

$$L = F_a / F_s \qquad (3)$$
$$Fs = 12.5(D_O)^2 \qquad (4)$$

where;

F_s = Soil resistance, kN/m.
L = Required length of the buried part of the pipe, m.
D_O = Outside diameter, m.

4. Finite Element Modeling

The finite element method combines, in an elegant way, the best features of many approximate methods. The technique is amenable to systematic computer programming and offers scope for application to a wide range of problems. The basic concept is that a body or structure may be divided into smaller elements of finite dimensions called "finite elements". The original body or the structure is then considered as an assemblage of these elements connected at a finite number of joints called "nodes" or "nodal points". The properties of the elements are formulated and combined to obtain the solution for the entire body or structure. One of the finite element commercial codes widely used in the research and designing process is ANSYS which is a finite element analysis software program [12].

The purpose of adopting ANSYS Program in this research is to study the effect of loads resulting from the internal pressure and temperature changes on the buried part of the pipeline without involving the response due to environmental loads.

Steel pipe Modeling

In the finite element formulation, the choice of the proper element is very important. The choice of the element type to be used for pipe idealization depends upon the geometry of the structure and upon the number of independent space coordinates necessary to describe the problem. For the present three-dimensional study, the buried pipeline is modeled using Solid45 (three-dimensional brick element) illustrated in Fig. (2) [12].

Solid45 is used for three-dimensional modeling of buried pipeline. The element is defined by eight nodes having three degrees of freedom at each node: translations in the x, y, and z directions.

Surrounding Soil Modeling

In this study, the soil is modeled using Combin14 spring element. This element has longitudinal capability in one, two, or three dimensional applications. The longitudinal Combin14 spring element option is a uniaxial tension-compression element with up to three degrees of freedom at each node, translations in the nodal x, y, and z directions, no bending or torsion are considered and it has no mass [12].

The geometry, node locations, and the coordinate system for this element are shown in Fig. (3). The element is defined by two nodes and a spring constant (k).

The soil is assumed as sandy soil, with horizontal bearing capacity of 192 kN/m2, which surrounding the buried pipeline. This soil is modeled using Combin14 spring element, which has three degrees of freedom at each node. Each spring element is fixed at the far end to simulate infinite extended soil mass. There are two types of Combin14 spring element, the first is normal to the faces of the pipeline to simulate the normal effect of the soil with coefficient of subgrade reaction (kn), while the other is tangent to the pipeline to simulate the shear effect of the soil with coefficient of subgrade reaction (ks).

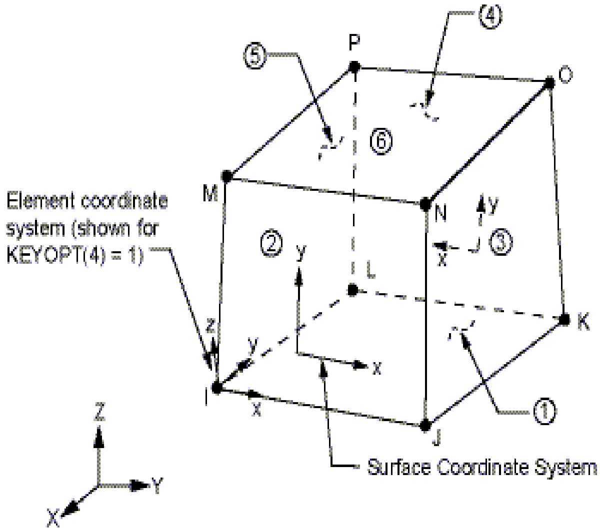

Fig. (2) Solid45, (3-D) buried pipeline element.

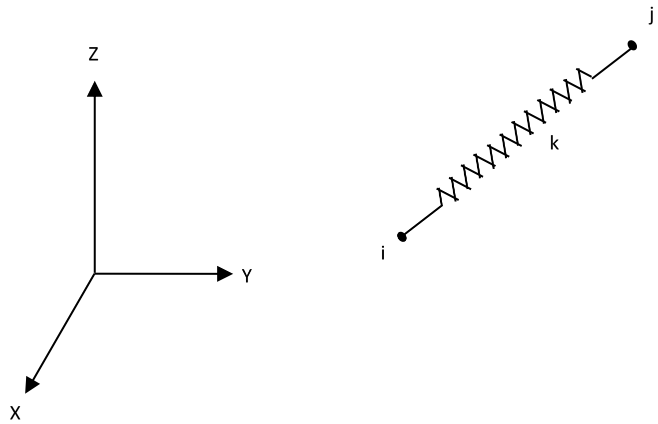

Fig. (3) Combin14 Element.

Nonlinear Behavior for Steel

In solid mechanics problems, there are two sources of nonlinearity. The first is due to non-linear material behavior and is usually referred to as material nonlinearity. The second is geometric nonlinearity which is caused by large deformations resulting in significant changes in the solid geometry.

In the present study, material nonlinearity due to nonlinear stress-strain relationship is considered.

5. Applications, Results and Discussion

In this study, the buried pipeline was analyzed by the finite element method (FEM), by adopting ANSYS 12.0 program. Figures (4 and 5) shows a typical model for the buried part of the pipeline. Number of the elements along the model depends on their length assuming that their thickness and width are constant.

A comprehensive study was carried out to investigate the effect of the various parameters which are expected to control the analysis, such as; length of the buried part, soil properties, depth of soil cover, and the end case of the buried part of the pipeline.

In this analysis the load is assumed to come from internal pressure and change of temperature (46 oC) where the load applied by assuming five equal incremental loads. This load is distribute equally on the all nodal points along the buried pipeline. The effect of the soil cover is presented as a pressure on the top of pipeline.

The properties of the materials and the symbols used to designate them are shown in Table (1).

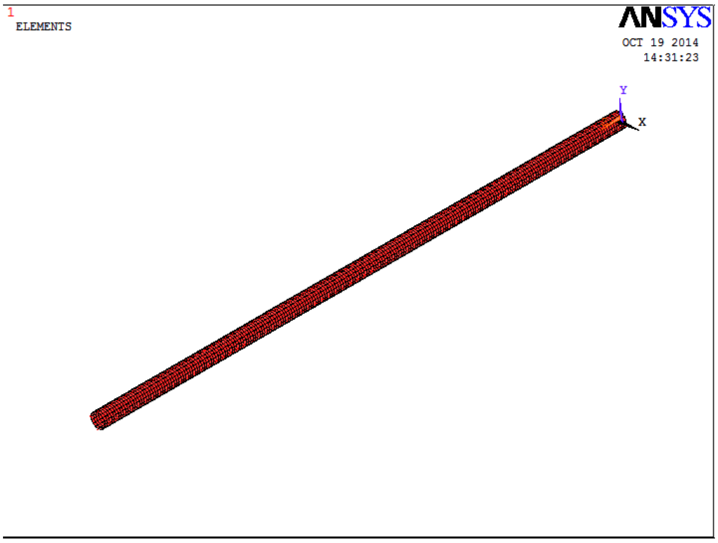

Fig. (4) A typical model for the buried pipeline.

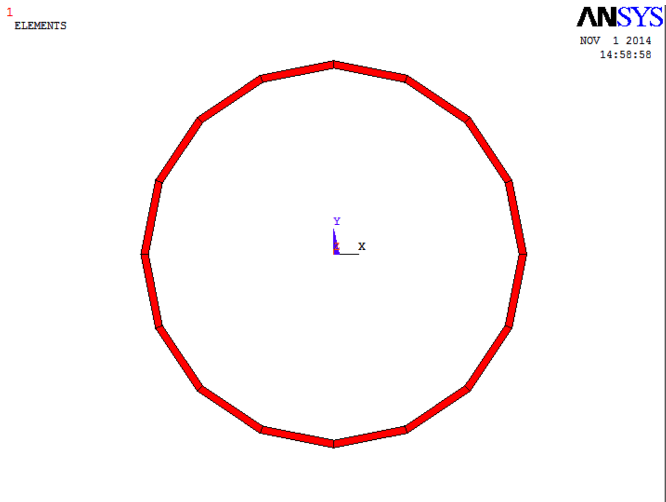

Fig. (5) A typical model for the buried pipeline–Front view.

Table (1) Properties of the buried pipeline and surrounding soil.

Material	Parameter	Symbol	Value
Soil	Unit weight (kN/m^3)	γ_{soil}	16
Steel pipe	Young's Modulus (kN/m^2)	E_s	2×10^8
	Poisson's ratio	υ_s	0.3
	Thermal expansion coefficient ($^\circ C^{-1}$)	α	10.8×10^{-6}

Effect of Buried Pipeline's Length

The adopted model to study the effect of pipeline's length is of (0.4064 m) outer diameter, wall thickness of (0.008 m), and (7929 kN/m2) design pressure, so the computed axial load given by Eq. (2), is (367 kN). The proposed length of the buried part of pipeline is computed using Eq. (3) is (180m).

The assumed values for normal (Kn) and tangent modulus (Ks) of subgrade reactions for the surrounding soil are (313322kN/m3 and 31332kN/m3, respectively). Soil cover above is assumed equal to (1m). One of the two ends of the buried part of the pipeline is fixed, while the other is free. The flow of the crude is assumed to run from the fixed end toward the free end.

Figure (6) shows that longitudinal displacement computed by the FEM, under the effect of applied load, at bottom face of the pipeline increases from fixed end toward the free end until it reaches maximum value (4.06 ×10-5 m) at (10%) of the pipeline length after which the longitudinal displacement have the same value with no change.

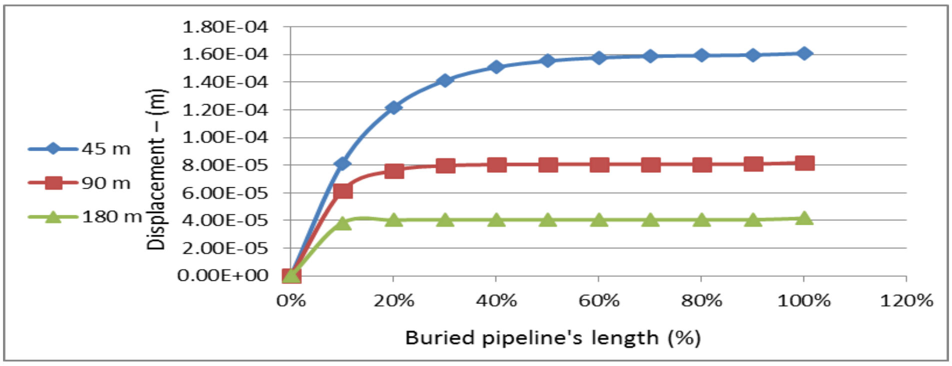

Fig. (6) Displacement–percentage of buried pipeline's length relationship for different values of length.

Due to the end fixed condition, maximum longitudinal stress and strain occur at fixed end of the pipeline and their values are (1014 kN/m2) and (5.16×10-6), respectively. As shown in Figs. (7 and 8), longitudinal stresses and strains values at bottom face of the pipeline decreases from the fixed end toward the far end until they reach their minimum values at (10%) of the pipeline length, thereafter, there are no change in the stress and strain until the other end.

Figures (6 to 8) show that same above behavior is observed for the adopted model when another values for buried part length are assumed. These values for pipeline length are (90m and 45m). Longitudinal displacement values are increase and both of stresses and strain values decrease with increasing distance toward the far end.

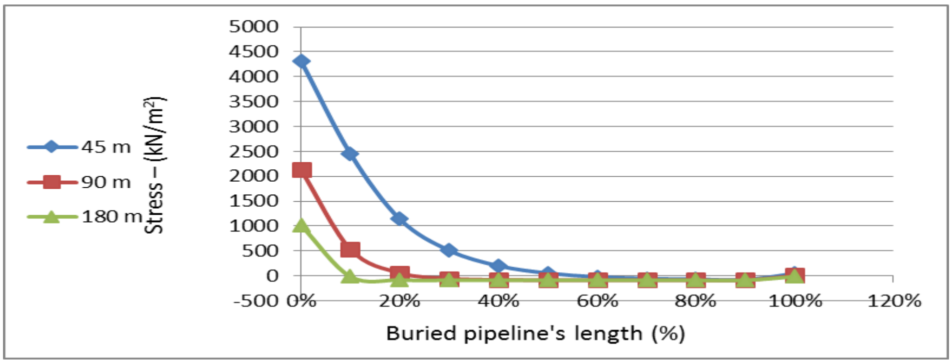

Fig. (7) Stresses–percentage of buried pipeline's length relationship for different values of length.

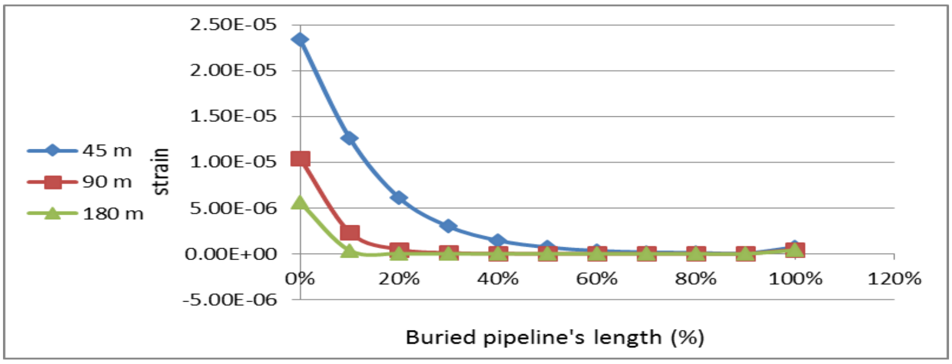

Fig. (8) Strains-percentage of buried pipeline's length relationship for different values of length.

For (90m) of buried pipeline length, maximum longitudinal displacement is (8.07×10-5m) which occurs at (30%) of buried part. Maximum longitudinal stress and strains at face of the pipeline are (2126 kN/m2) and (1.04×10-5), respectively. After (30%) of the buried part, values of longitudinal displacements, stresses, and strains have same values toward the far free end of the pipe.

The same behavior is shown for length (45 m) of the buried length. Maximum longitudinal displacement is (1.6×10-4 m) occurring at (60%) of the buried pipeline's length. Maximum longitudinal stress and strain are (4313.9 kN/m2 and 2.34×10-5, respectively). After (60%) of the buried pipeline length there are no change in the values of longitudinal displacements, stresses, and strains. Table (2) shows results of maximum values for longitudinal displacements, stresses, and strains.

Table (2) Values of max. displacement, stresses, and strains for different values of buried pipeline's length.

Assumed pipeline length LAssu. (m)	LAssu./L	Max. displacement (m)	Max. stress (kN/m^3)	Max. strain
180	1.00	4.06 ×10-5	1014.0	5.16×10-6
90	0.50	8.07×10-5	2126.0	1.04×10-5
45	0.25	1.60×10-4	4313.9	2.34×10-5

It can be seen that increasing the length of buried part of the pipeline causes decreasing in the values of longitudinal displacements, stresses, and strains, due to increasing of the surface area of buried part of the pipeline and that leads to increase friction between the pipes and surrounding soil.

It can be seen from Figs. (6 to 8), there are some increase in the values of longitudinal displacements, stresses, and strains at the free end of the pipe. This behavior can be illustrated due to the free condition of the far end.

Effect of Soil Properties

In the problems of soil-structural interaction, the effect of soil properties on the behavior of structures depends on many parameters, such as characteristics of the soil in addition to the properties of the structure.

Using the same previous model with buried length of (180m), the effect of soil properties on the behavior of the buried pipeline is studied in the sandy soil using three different values for the normal and tangential modulus of subgrade reaction (kn and ks, respectively), as given in Table (3), where the values of (ks) equal to (0.125kn).

Table (3) Values of max. displacement, stresses, and strains for different values of normal and tangential modulus of subgrade reaction.

Modulus of subgrade reaction (kN/m^3)		Max. displacement (m)	Max. stress (kN/m^2)	Max. strain
k_n	k_s			
250658	31332	5.07×10^{-5}	1150.8	6.30×10^{-6}
313322	39166	4.06×10^{-5}	1014.0	5.61×10^{-6}
375987	46998	3.40×10^{-5}	911.0	5.00×10^{-6}

As it can be seen from Fig. (9), that the maximum longitudinal displacement occurs after (20%) of buried pipeline's length, as shown in Fig. (9). All the values of longitudinal displacements, stresses and strains seem stable after (20%) from buried pipeline's length, as shown in Figs. (9 to 11).

Increasing the values of kn from (250658kN/m3 to 313322kN/m3) leads to decrease maximum longitudinal displacement about 19.9%, maximum longitudinal stress decreases about 11.88%, and maximum longitudinal strain decreases about 10.95%. Also, increasing (kn) from (250658 kN/m3 to 375987 kN/m3) leads to decrease maximum longitudinal displacement about 32.94%, maximum longitudinal stress decreases about 20.8% and maximum longitudinal strain decreases about 20.6%.

It is clear from Figs. (9 to 11), that the increase in values of modulus of subgrade reaction of the soil causes a decrease in values of longitudinal displacements, stresses and strains in buried pipeline. This behavior may be explained as that the increase of modulus of subgrade reaction of soil leads to increase the soil resistance to movement of the pipe. Also, it can be seen that there are some increase in the values of longitudinal displacements, stresses, and strain at the free end of the pipe where this behavior can be illustrated due to the free condition of the far end, as mentioned previously.

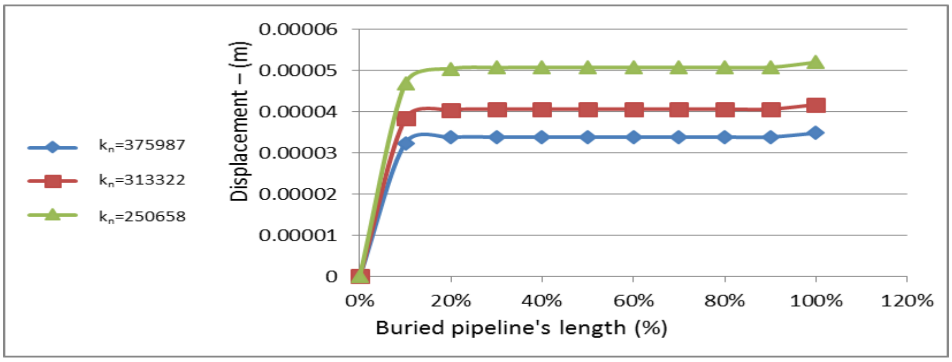

Fig. (9) Displacement–percentage of buried pipeline's length relationship for different values of (k_n and k_s).

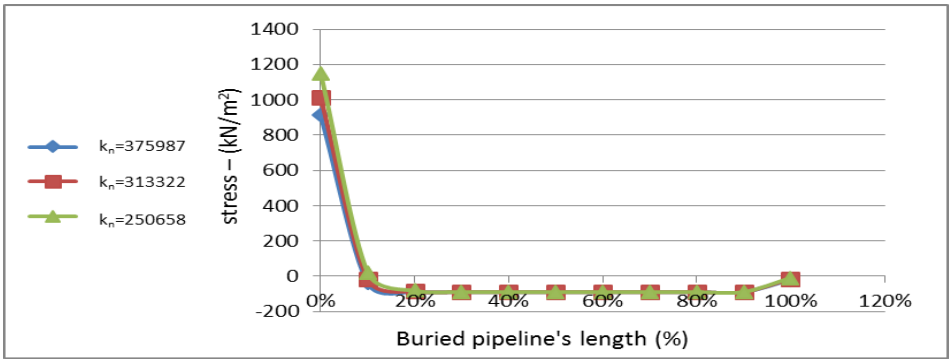

Fig. (10) Stresses–percentage of buried pipeline's length relationship for different values of (k_n and k_s).

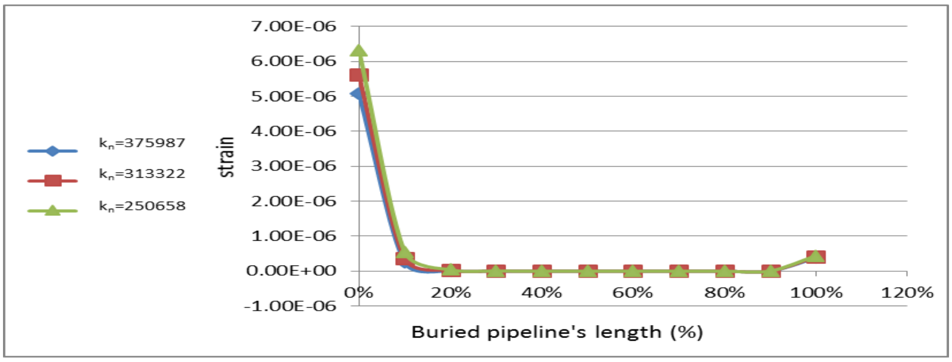

Fig. (11) Strain–percentage of buried pipeline's length relationship for different values of (k_n and k_s).

Effect of Soil Cover Depth

Most pipelines are buried at shallow depths below the ground for the ease of installation and access during maintenance or repair.

In this study, three suggested different values for depth of the soil cover (1m, 1.5m, and 2 m) are studied for the Model which have buried length of (180). The same general behavior which is discussed in the previous clauses can be noticed in this clause. Under the effect of applied load, longitudinal displacement increases from fixed end of pipeline toward the far end until it reaches maximum value of (4.06×10-5m) at a distance of (20%) from the buried pipeline's length for all depths values of soil cover, as it is shown in Table (4) and Fig. (12).

Table (4) Values of Maximum displacements, stresses, and strains for Different Values of Soil Cover Depth.

Depth of soil cover (m)	Max. Displacement (m)	Max. stresses (kN/m^2)	Max. strain
1	4.06×10^{-5}	1014.0	5.61×10^{-6}
1.5	4.06×10^{-5}	1029.9	5.74×10^{-6}
2	4.06×10^{-5}	1052.5	6.09×10^{-6}

Longitudinal stresses and strains have their maximum values at fixed end, and these values decrease with increasing distance from the fixed end until they reach minimum values at distance (20%) from the buried length after which they have very close values until the far end, as shown in Figs. (13 and 14).

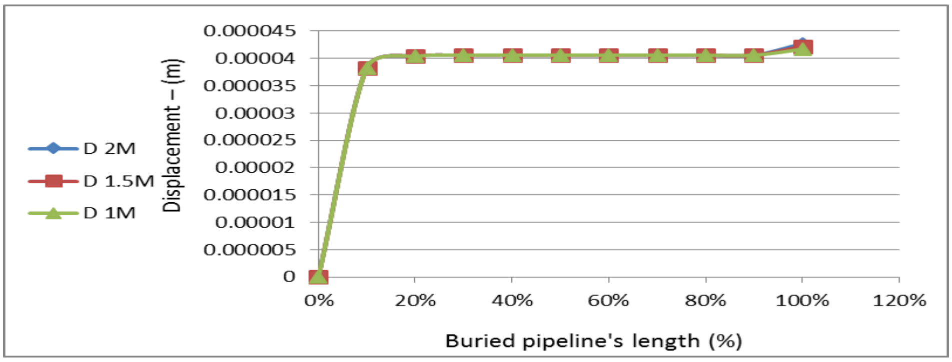

Fig. (12) Displacement–percentage of buried pipeline's length relationship for different values of depth of soil cover.

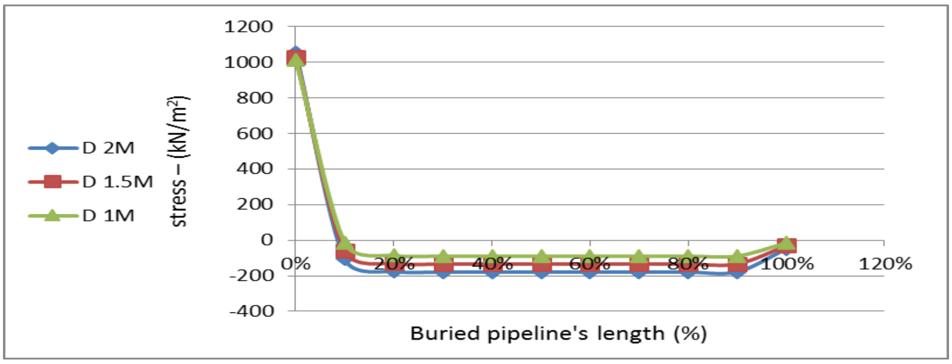

Fig. (13) Stresses–percentage of buried pipeline's length relationship for different values of depth of soil cover.

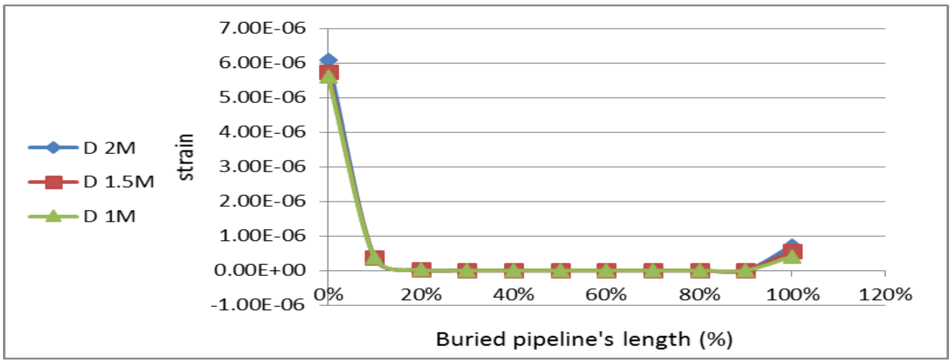

Fig. (14) Strain–percentage of buried pipeline's length relationship for different values of depth of soil cover.

As shown from Table (4), when the depth of soil cover increased from (1m to 1.5m), the maximum longitudinal displacement still unchanged, while maximum longitudinal stress and strain increased about (1.57%) and (2.32%), respectively. But when the depth increased to (2m), maximum longitudinal displacement still unchanged compared to that values of (1m) depth, while maximum longitudinal stress and strains increased about (3.8%) and (8.56%), respectively.

This can be explained because of the length of this model is large enough so that it did not much affected by increasing the depth of soil cover.

Effect of End Conditions for Buried Pipeline

The ends of pipeline may be fixed (fully restrained) or free (unrestrained), in this study, two different cases; fixed–free and fixed–fixed are considered, and a comparison between results of displacements, stresses and strains is made. Assuming (1m) for soil cover depth.

Behavior of the studied model under the effect of applied load, for the two cases of end conditions, is illustrated in Figs. (15 to 17). This behavior for the case of fixed-free end conditions was discussed previously. In the case of fixed-fixed end condition, displacement values at the bottom of the pipe increase from the fixed end until they reach their maximum values at distance (36 m) from both two ends, where these values still unchanged between them, as shown in Fig. (15).

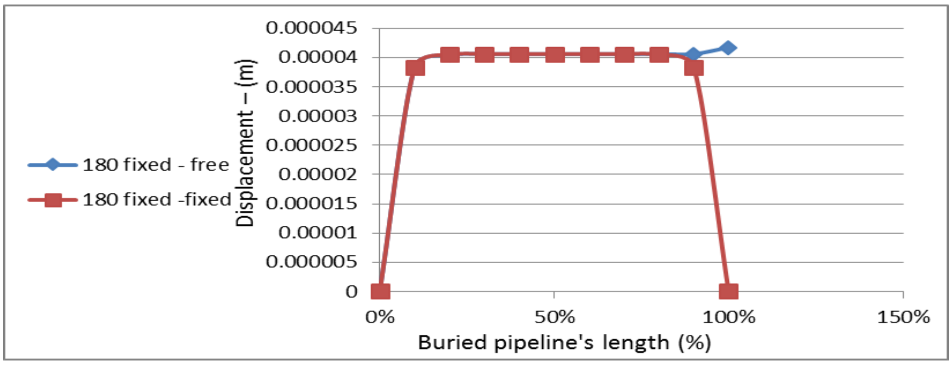

Fig. (15) Displacement–percentage of buried pipeline's length relationship for two ends conditions

Longitudinal stresses decrease from maximum values at the fixed ends until they have a constant values at distance (36m) from both two ends, where there are no change in the values of stress between them. The same behavior can notice for strain values, as shown in Figs. (16 and 17).

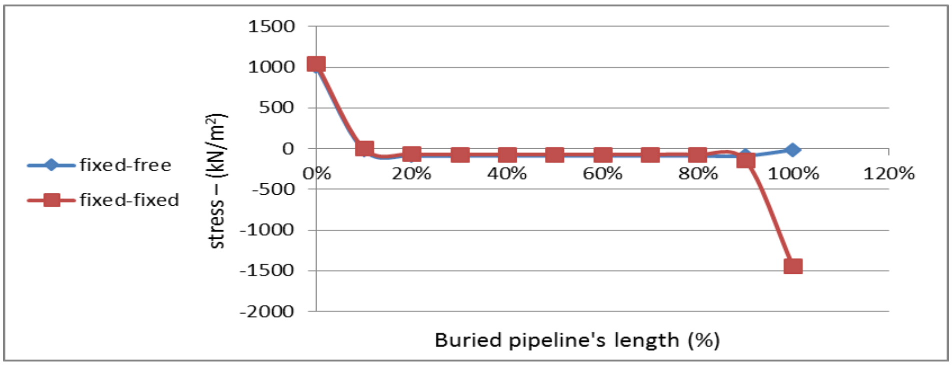

Fig. (16) Stresses–percentage of buried pipeline's length relationship for two ends conditions.

It can be notice from the above figures, in the case of fixed-fixed end, the longitudinal stress at far fixed end is larger compared to that of near end, while longitudinal strain values at near fixed end is larger compared to that of far one.

Table (5) shows the maximum values of longitudinal displacements, stresses, and strains for the two cases of end conditions. It can be seen from this table that the maximum displacement was not affected by changing the condition of the far end from free to fixed case. But the longitudinal stresses and strains, at the nearest end, increased about (2.95% and 2.5%), respectively due to changing of the case of the far end from free to fixed condition.

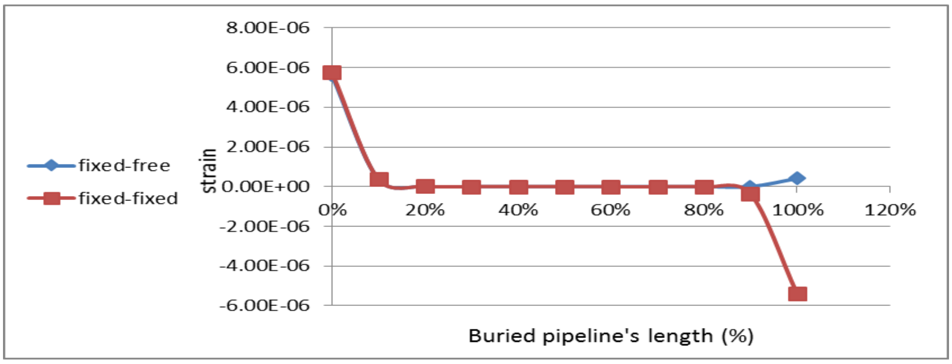

Fig. 17 Strain–percentage of buried pipeline's length relationship for two ends conditions.

Table (5) Analysis Results of Different End Boundary Conditions

Ends condition	Max. disp. (m) ($\times10^{-5}$)	Max. stresses (kN/m^2)		Max. strain ($\times10^{-6}$)	
		Near End	Far end	Near end	Far End
Fixed-Free	4.06	1014	-15	5.61	0.41
Fixed-Fixed	4.06	1044	-1446	5.75	-5.4

6. Conclusions

Based on the finite element analysis carried throughout the present study, the following conclusions can be drawn;

1- A simplified static model for the buried pipeline based on finite element method is performed using ANSYS program. This model is quite simple and practicable for studying different parameters. An efficient Newton's method procedure was adopted for the solution of the system of nonlinear algebraic equations. The stiffness, required by the Newton's method were adopted and give acceptable results.

2- The longitudinal displacement, stress and strain are inversely proportional with the buried pipeline's length, where increasing the length of buried part of the pipeline causes decreasing in the values of longitudinal displacements, stresses, and strains, due to increasing of the surface area of buried part of the pipeline that leads to increase friction between the pipes and surrounding soil.

3- The increase in values of modulus of subgrade reaction of the soil causes decreasing in the values of longitudinal displacements, stresses and strains in buried pipeline.

4- Height of soil cover depth has very small effect on longitudinal displacement. But increasing soil cover depth leads to increase longitudinal stresses and strains in the buried pipelines.

5- Changing case of the far end condition from free to restraint (fixed), have no any effect on the value of maximum displacement and small effect on the values of maximum longitudinal stress and strain.

6- All longitudinal displacement and stresses do not exceed the specified limit values in the adopted codes.

Conflicts of Interest

The author declares that they have no conflicts of interest.

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تحليل الاجهاد لخط الانابيب المدفون بأستخدام طريقة العناصر المحدودة

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الخلاصة

تهدف هذه الدراسة إلى تحليل سلوك الجزء المدفون تحت الارض من أنابيب الصلب تحت تأثير الأحمال الناجمة عن الضغط الداخلي وتباين درجات الحرارة بسبب نقل المنتجات الهيدروكربونية. على افتراض أن خط الأنابيب مدفون في تربة رملية، وباعتماد طريقة العناصر المحددة لتنفيذ هذا التحليل باستخدام برنامج ANSYS 12.0. تم دراسة تأثير أربع متغيرات منها طول الجزء المدفون من الانبوب، خواص التربة، وعمق غطاء التربة، وحالة التقييد لنهايتي الجزء المدفون من الانبوب. حيث تبين أن زيادة طول الجزء المدفون أو زيادة قيم معاملات رد فعل التربة العمودية والمماسية للجزء المدفون من الأسباب المؤدية الى انخفاض في قيم الازاحات الطولية، والإجهاد، والانفعال. كما أن عمق غطاء التربة على الجزء المدفون من الانبوب ليس له أي تأثير على النزوح الطولي، ولكن الاجهادات والانفعالات زادت عند زيادة عمق غطاء التربة. من دراسة تأثير حالة التقييد لطرفي الجزء المدفون، وجدت أن الحد الأقصى للازاحات الطولية لم تتأثر، ولكن قيم الاجهادات والانفعالات الطولية زادت بمقادير صغيرة.

الكلمات الدالة: الانابيب المدفونة، العناصر المحددة، ازاحات الانابيب المدفونة، الضغط الداخلي في الانابيب، تداخل التربة مع الانابيب، تثبيت الانابيب المدفونة