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SUBMARINE SHELL ELEMENT STATIC LINEAR DEFORMATION ANALYSIS

İsmail BAYER [1]
Kerem YILMAZ [2]

[1]*Faculty of Naval Architecture and Marine Engineering, Yildiz Technical University,*
bayer@ytu.edu.tr,
[2] *National Defence University Barbaros Naval Sciences and Engineering Institute,*
keremyilmaz6146@gmail.com

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ABSTRACT

In this paper; a submarine vessel's shell element's deformation has been investigated due to hydrotatic pressure. Eleven different pressure value for eleven depth has been accounted. A doubly curved shell element within different radius and different lenghts of edges is analysed by using numerical method solution of static linear equilibrium equation of shell element. In the solution part, Navier Solution method with double Fourier series is used for solution of final differantial equations. Identical shell element has been analysed in a package program ANSYSTM in order to verification of solution. Following of verification, cylindrical shell element has been analysed with numerical method. In numerical analysis a MATLABTM code is written for easy solution for different curvature radiuses and different lenghts of edges. After all solution analyses, stres components of shell elements has been compared with Turkis Loyd permitted stress components for design of a submarine. As a result, it's studied on deformation of isotropic shell element according to different length-thickness ratio and length values.

ÖZ

Bu makalede, dalmış durumdaki bir denizaltı kabuki elemanı üzerinde hidrostatik basınç nedeniyle oluşan deformasyonu incelenmiştir. On bir farklı derinlikteki basınç değeri için kabuki üzerinde oluşan deformasyon hesaplanmıştır. Denizaltıya ait çift taraflı eğimli bir kabuki eleman farklı eğrilik yarıçap değerleri ve farklı kenar uzunlukları için static lineer denge denklemlerinin sayısal çözümü ile deformasyon analizi yapılmıştır. Denge denklemlerinin çözümünde kurulan diferansiyel denklemlerin çözümünde Navier yöntemi ile çift Fourier serileri analizi kullanılmıştır. Yapılan çözümün kontrolü kapsamında yanı özelliklere sahip kabuk eleman ticari paket program ANSYSTM ile lineer deformasyon analizi yapılmıştır. Çözüm doğrulamanın ardından bir silindirik kabuki *elemanın aynı derinliklerdeki deformasyon analizi gerçekleştirilmiştir. Sayısal çözümler esnasında elde edilen deklemlerin çözümü için MATLABTM kodu kullanılmmıştır. Bu kod ile farklı eğrilik yarıçapları ve farklı kenar uzunlukları için kabuki elemanın deformasyon analizi kolaylaşmıştır. Tüm analizlerin devamında kabuki üzerinde meydana gelen gerilme bileşenleri Türk Loydu içerisinde denizaltı dizaynında izin verilen gerilme değerleri ile karşılaştırılmıştır. Sonuç olarak; izotropik bir denizaltı kabuğunun farklı eğrilik yarıçap ve kenar uzunlukları için deformasyon analizi yapılmıştır.*

Keywords: *Thin shell, doubly curved shell, Fourier analysis, submarine shell, deformation of thin shell.*
Anahtar Kelimeler: *İnce kabuki, çift eğrili kabuki, Fourier analizi, Denizaltı kabuğu, İnce kabuki deformasyonu.*

1. INTRODUCTION

HY-80, HY-100 steels are used in submarine vessels widely. These steels are highly strong and durable under high pressures. Submarine vessels consist of shell elements. Shell elements of submarines are mostly take part in engineering as thin shells due to ratio of length and thickness. It’s an important point to make deformation, buckling analysis in design section. For numerical problem solution of isotropic shell deformation analysis it’s been seen the similar equations for static lineer equilibrium equation suggested by Köksal [1], Ventsel and Krauthammer [2].

2. PROBLEM DEFINITION

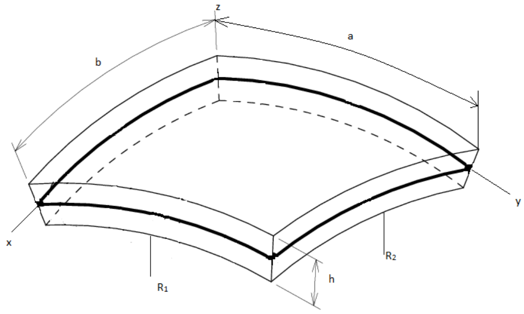

Figure 1. Doubly curved shell element

A doubly curved shell with R_1, R_2 curvature radiuses, a and b lengths of edges, h thickness values.

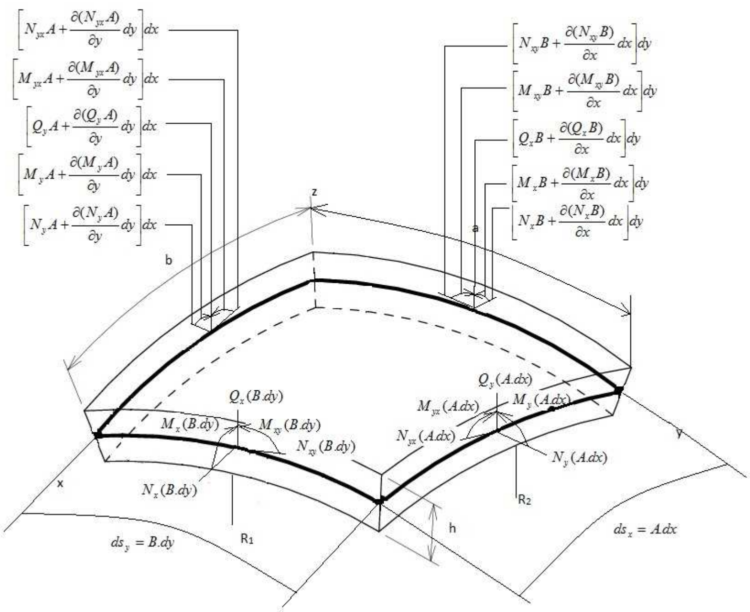

Figure 2. Forces and moments on shell element

All force and moment components take part in figure 2. N_x and N_y are normal force components, N_{xy} and N_{yx} are shear force components, M_x and M_y are bending moment components, Q_x and Q_y are shear force components.
When total forces and total moments are equated zero according to axis x,y and z, we get to equilibrium of shell element.

$$\frac{1}{AB}\left[\frac{\partial(N_x B)}{\partial x}+\frac{\partial(N_{xy}A)}{\partial y}-\frac{\partial B}{\partial x}N_y+\frac{\partial A}{\partial y}N_{xy}\right]-\frac{Q_x}{R_1}+q_x=0$$

$$\frac{1}{AB}\left[\frac{\partial(N_y A)}{\partial y}+\frac{\partial(N_{xy}B)}{\partial x}-\frac{\partial A}{\partial y}N_x+\frac{\partial B}{\partial x}N_{xy}\right]-\frac{Q_y}{R_2}+q_y=0$$

$$\frac{1}{AB}\left[\frac{\partial(Q_x B)}{\partial x}+\frac{\partial(Q_y A)}{\partial y}\right]+\frac{N_x}{R_1}+\frac{N_y}{R_2}+q_z=0$$

$$\frac{1}{AB}\left[\frac{\partial(M_x B)}{\partial x}-\frac{\partial B}{\partial x}M_y+\frac{\partial A}{\partial y}M_{xy}+\frac{\partial(M_{xy}A)}{\partial y}\right]-Q_x=0$$

$$\frac{1}{AB}\left[\frac{\partial(M_y A)}{\partial y}-\frac{\partial A}{\partial y}M_x+\frac{\partial B}{\partial x}M_{xy}+\frac{\partial(M_{xy}B)}{\partial x}\right]-Q_y=0$$

(1)

q_x, q_y and q_z symbolize the forces or loads according to axis. At this point; q_x and q_y equals zero since no force or load at these axis. In these equations; A and B are lame parameters for definition of surface form.
Eqs (1) can be eased by reducing five equation into three by replacing Q_x and Q_y components with M_x, M_y, M_{xy} components. In addition; derivations of lame parameters are negligible compared to force or moment derivations.

$$\frac{1}{AB}\left[\frac{\partial N_x}{\partial x}B+\frac{\partial N_{xy}}{\partial y}A\right]-\frac{1}{ABR_1}\left[\frac{\partial M_x}{\partial x}B+\frac{\partial M_{xy}}{\partial y}A\right]=0$$
$$\frac{1}{AB}\left[\frac{\partial N_y}{\partial y}A+\frac{\partial N_{xy}}{\partial x}B\right]-\frac{1}{ABR_2}\left[\frac{\partial M_y}{\partial y}A+\frac{\partial M_{xy}}{\partial x}B\right]=0$$
$$\frac{1}{AB}\left[B\left(\frac{\partial^2 M_x}{\partial x^2}\frac{1}{A}+\frac{\partial^2 M_{xy}}{\partial x\partial y}\frac{1}{B}\right)+A\left(\frac{\partial^2 M_y}{\partial y^2}\frac{1}{B}+\frac{\partial^2 M_{xy}}{\partial x\partial y}\frac{1}{A}\right)\right]+\frac{N_x}{R_1}+\frac{N_y}{R_2}+q_z=0$$
(2)

Let us replace N and M components with displacement components for solution of these equations. Isotropic shell linner elasticity relation for N and M components in the following equations.

$$\begin{Bmatrix} N_x \\ N_y \\ N_{xy} \\ M_x \\ M_y \\ M_{xy} \end{Bmatrix} = \begin{bmatrix} C & \nu.C & 0 & 0 & 0 & 0 \\ \nu.C & C & 0 & 0 & 0 & 0 \\ 0 & 0 & \frac{1-\nu}{2}.C & 0 & 0 & 0 \\ 0 & 0 & 0 & D & \nu.D & 0 \\ 0 & 0 & 0 & \nu.D & D & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{1-\nu}{2}.D \end{bmatrix} . \begin{Bmatrix} \varepsilon_x \\ \varepsilon_y \\ \gamma_{xy} \\ k_x \\ k_y \\ k_{xy} \end{Bmatrix}$$

$$C=\frac{Eh}{(1-\nu^2)}$$
$$D=\frac{Eh^3}{12(1-\nu^2)}$$
(3)

C represents elongation rigidity, D represents flexure rigidity, E is elasticity module, h is thickness of shell, v is poisson ratio. We can write the following equations for isotropic thin shell [1];

$$\varepsilon_x = \frac{1}{A}\frac{\partial u}{\partial x} + \frac{w}{R_1} \qquad k_x = -\frac{1}{A^2}\frac{\partial^2 w}{\partial x^2}$$

$$\varepsilon_y = \frac{1}{A}\frac{\partial v}{\partial y} + \frac{w}{R_2} \qquad k_y = -\frac{1}{B^2}\frac{\partial^2 w}{\partial y^2}$$

$$\gamma_{xy} = \frac{1}{B}\frac{\partial u}{\partial y} + \frac{1}{A}\frac{\partial v}{\partial x} \qquad k_{xy} = \frac{\partial^2 w}{\partial x \partial y}$$

Rewriting N and M components with given displacement and curvature equations.

$$N_x = C\left[\frac{1}{A}\frac{\partial u}{\partial x} + \frac{w}{R_1} + \nu\left(\frac{1}{B}\frac{\partial v}{\partial y} + \frac{w}{R_2}\right)\right]$$

$$N_y = C\left[\frac{1}{B}\frac{\partial v}{\partial y} + \frac{w}{R_2} + \nu\left(\frac{1}{A}\frac{\partial u}{\partial x} + \frac{w}{R_1}\right)\right]$$

$$N_{xy} = C\frac{1-\nu}{2}\left[\frac{1}{A}\frac{\partial v}{\partial x} + \frac{1}{B}\frac{\partial u}{\partial y}\right]$$

$$M_x = -D\left[\frac{1}{A^2}\frac{\partial^2 w}{\partial x^2} + \nu\left(\frac{1}{B^2}\frac{\partial^2 w}{\partial y^2}\right)\right]$$

$$M_y = -D\left[\frac{1}{B^2}\frac{\partial^2 w}{\partial y^2} + \nu\left(\frac{1}{A^2}\frac{\partial^2 w}{\partial x^2}\right)\right]$$

$$M_{xy} = -D(1-\nu)\left[\frac{\partial^2 w}{\partial x \partial y}\right]$$

(4)

Using Eqs (4) in Eqs (2) we get following equations.

$$\frac{C}{AB}\left[B\left(\frac{1}{A}\frac{\partial^2 u}{\partial x^2}+\frac{1}{R_1}\frac{\partial w}{\partial x}+v\left(\frac{1}{B}\frac{\partial^2 v}{\partial x\partial y}+\frac{1}{R_2}\frac{\partial w}{\partial x}\right)\right)+A\frac{1-v}{2}\left(\frac{1}{A}\frac{\partial^2 v}{\partial x\partial y}+\frac{1}{B}\frac{\partial^2 u}{\partial y^2}\right)\right]$$
$$-\frac{1}{R_1 AB}\left[-DB\left(\frac{1}{A^2}\frac{\partial^3 w}{\partial x^3}+v\left(\frac{1}{B^2}\frac{\partial^3 w}{\partial x\partial y^2}\right)\right)-DA(1-v)\frac{\partial^3 w}{\partial x\partial y^2}\right]=0$$
$$\frac{C}{AB}\left[A\left(\frac{1}{B}\frac{\partial^2 v}{\partial y^2}+\frac{1}{R_2}\frac{\partial w}{\partial y}+v\left(\frac{1}{A}\frac{\partial^2 u}{\partial x\partial y}+\frac{1}{R_1}\frac{\partial w}{\partial y}\right)\right)+B\frac{1-v}{2}\left(\frac{1}{A}\frac{\partial^2 v}{\partial x^2}+\frac{1}{B}\frac{\partial^2 u}{\partial x\partial y}\right)\right]$$
$$-\frac{1}{R_2 AB}\left[-DA\left(\frac{1}{B^2}\frac{\partial^3 w}{\partial y^3}+v\left(\frac{1}{A^2}\frac{\partial^3 w}{\partial x^2\partial y}\right)\right)-DB(1-v)\frac{\partial^3 w}{\partial x^2\partial y}\right]=0$$
$$\frac{1}{AB}\left\{\begin{array}{l}B\left[-D\frac{1}{A}\left(\frac{1}{A^2}\frac{\partial^4 w}{\partial x^4}+v\frac{1}{B^2}\frac{\partial^4 w}{\partial x^2\partial y^2}\right)+\frac{1}{B}\left(-D(1-v)\frac{\partial^4 w}{\partial x^2\partial y^2}\right)\right]\\+A\left[\frac{1}{B}\left(\frac{-D}{B^2}\frac{\partial^4 w}{\partial y^4}-Dv\frac{1}{A^2}\frac{\partial^4 w}{\partial x^2\partial y^2}\right)-\frac{1}{A}D(1-v)\frac{\partial^4 w}{\partial x^2\partial y^2}\right]\end{array}\right\}$$
$$+\frac{C}{R_1}\left[\frac{1}{A}\frac{\partial u}{\partial x}+\frac{w}{R_1}+v\left(\frac{1}{B}\frac{\partial v}{\partial y}+\frac{w}{R_2}\right)\right]+\frac{C}{R_2}\left[\frac{1}{B}\frac{\partial v}{\partial y}+\frac{w}{R_2}+v\left(\frac{1}{A}\frac{\partial u}{\partial x}+\frac{w}{R_1}\right)\right]=-q_z$$

(5)

3. DOUBLE FOURİER SERIES

Using double Fourier series with Naiver Solution on Simply-Supported elements. In Fourier series, assigning u,v and w displacements according to boundary condition with following series;

$$u(x,y)=\sum_{m=0}^{\infty}\sum_{n=1}^{\infty}U_{mn}\cos\alpha x\sin\beta y \qquad 0\le x\le a\ ,\ 0\le y\le b$$

(6.a)

$$v(x,y)=\sum_{m=1}^{\infty}\sum_{n=0}^{\infty}V_{mn}\sin\alpha x\cos\beta y \qquad 0\le x\le a\ ,0\le y\le b$$

(6.b)

$$w(x,y)=\sum_{m=1}^{\infty}\sum_{n=1}^{\infty}W_{mn}\sin\alpha x\sin\beta y \qquad 0\le x\le a\ ,\ 0\le y\le b$$

(6.c)

In Eqs (6);

$$\alpha=\frac{m\pi}{a}$$

$$\beta=\frac{n\pi}{b}$$

Now the displacement values in Eqs (5) must be replaced with proper derivatives of Eqs (6).

Example for derivatives;

$$\frac{\partial^2 u}{\partial x^2}=-\sum_{m=0}^{\infty}\sum_{n=1}^{\infty}U_{mn}\alpha^2\cos\alpha x\sin\beta y$$

$$\frac{\partial^2 u}{\partial y^2}=-\sum_{m=0}^{\infty}\sum_{n=1}^{\infty}U_{mn}\beta^2\cos\alpha x\sin\beta y$$

After replacement final equations we obtain the following:

$$\sum_{m=1}^{\infty}\sum_{n=0}^{\infty}\sin\alpha x\cos\beta y\left\{\begin{array}{c} C\alpha\beta\left[-\frac{\nu}{AB}-\frac{(1-\nu)}{2AB}\right]U_{mn} \\ C\left[-\frac{\beta^2}{B^2}-\frac{(1-\nu)\alpha^2}{2A^2}\right]V_{mn} \\ \frac{C\beta}{B}\left[\frac{1}{R_2}+\frac{\nu}{R_1}\right]+\frac{D\beta}{R_2}\left[-\frac{\beta^2}{B^3}-\frac{\nu\alpha^2}{A^2B}-\frac{(1-\nu)\alpha^2}{A}\right]W_{mn} \end{array}\right\}=0$$

$$\sum_{m=0}^{\infty}\sum_{n=1}^{\infty}\cos\alpha x\sin\beta y\left\{\begin{array}{c} C\left[-\frac{\alpha^2}{A^2}-\frac{(1-\nu)}{2B^2}\beta^2\right]U_{mn} \\ \frac{C\alpha\beta}{AB}\left[-\nu-\frac{(1-\nu)}{2}\right]V_{mn} \\ \frac{C\alpha}{A}\left(\frac{1}{R_1}+\frac{\nu}{R_2}\right)-\frac{D\alpha}{R_1}\left(\frac{\alpha^2}{A^3}+\frac{\nu\beta^2}{AB^2}+\frac{(1-\nu)\beta^2}{B}\right)W_{mn} \end{array}\right\}=0$$

(7)

$$\sum_{m=1}^{\infty}\sum_{n=1}^{\infty}\sin\alpha x\sin\beta y\left\{\begin{array}{c} C\alpha\left[-\frac{\nu}{AR_2}-\frac{1}{AR_1}\right]U_{mn} \\ C\beta\left[-\frac{\nu}{BR_1}-\frac{1}{BR_2}\right]V_{mn} \\ D\left[-\frac{\alpha^4}{A^4}-\frac{2\nu\alpha^2\beta^2}{A^2B^2}-\frac{2(1-\nu)\alpha^2\beta^2}{AB}-\frac{\beta^4}{B^4}\right] \\ +C\left[\frac{1}{R_1{}^2}+\frac{2\nu}{R_1R_2}+\frac{1}{R_2{}^2}\right]W_{mn} \end{array}\right\}=-q_z$$

4. PROBLEM SOLUTION

In chapter 3 we have final equations need to be resolved (Eqs(7)). The Fourier coefficient W_{mn} gives us the deformation in axis z after solving W_{mn} with Navier Solution. In this step a MATLAB^{TM} code is created for solution Eqs (7) and W_{mn}. With similar geometric features same problem solved in ANSYS^{TM} with Shell91 input data to correct numerical solution. In the following table ANSYS^{TM} and MATLAB^{TM} results are located.

Table 1. Deformation analyse in ANSYS and MATLAB

		Deformation(mm)			
Depth (m)	*Hydrostatic pressure (kPa)*	**MATLAB**	**ANSYS**	**MATLAB**	**ANSYS**
		a/h=10 a/b=1		*a/h=15 a/b=1*	
100	1005.525	**0.456**	**0.482**	**1.600**	**1.630**
150	1508.2875	**0.685**	**0.723**	**2.401**	**2.445**
200	2011.05	**0.913**	**0.964**	**3.201**	**3.261**
250	2513.8125	**1.141**	**1.205**	**4.001**	**4.076**
300	3016.575	**1.370**	**1.446**	**4.802**	**4.891**
350	3519.3375	**1.598**	**1.687**	**5.603**	**5.707**
400	4022.1	**1.827**	**1.928**	**6.403**	**6.523**
450	4524.8625	**2.055**	**2.169**	**7.203**	**7.337**
500	5027.625	**2.283**	**2.410**	**8.004**	**8.153**
550	5530.3875	**2.512**	**2.652**	**8.805**	**8.969**
600	6033.15	**2.740**	**2.893**	**9.605**	**9.785**

The analysis made with length-thickness ratio; a/h=10, 15 values.It's seen that our numerical solution and ANSYS analysis results close enough to be sure that numerical solution is correct and valid. Now we can get the different curvature radiuses and different lengths of edges shell deformation results using numerical solution. Following tables contain these solutions.

Table 2. Solution of a/h=10,15,20 shell element deformations

		Deformation (mm)		
Depth (m)	*Hydrostatic pressure (kPa)*	*a/h=10 a/b=1*	*a/h=15 a/b=1*	*a/h=20 a/b=1*
100	1005.525	**0.456**	**1.600**	**4.009**
150	1508.2875	**0.685**	**2.401**	**6.015**
200	2011.05	**0.913**	**3.201**	**8.022**
250	2513.8125	**1.141**	**4.001**	**10.025**
300	3016.575	**1.370**	**4.802**	**12.031**
350	3519.3375	**1.598**	**5.603**	**14.038**
400	4022.1	**1.827**	**6.403**	**16.045**
450	4524.8625	**2.055**	**7.203**	**18.047**
500	5027.625	**2.283**	**8.004**	**20.054**
550	5530.3875	**2.512**	**8.805**	**22.060**
600	6033.15	**2.740**	**9.605**	**24.067**

Table 3. Solution of a/h=10-a/b=1,0.8 and a/h=15-a/b=1,0.8 shell element deformations

		Deformation (mm)			
Depth (m)	*Hydrostatic pressure (kPa)*	*a/h=10 a/b=1*	*a/h=10 a/b=0.8*	*a/h=15 a/b=1*	*a/h=15 a/b=0.8*
100	1005.525	**0.456**	**0.689**	**1.600**	**2.464**
150	1508.2875	**0.685**	**1.034**	**2.401**	**3.698**
200	2011.05	**0.913**	**1.379**	**3.201**	**4.931**
250	2513.8125	**1.141**	**1.723**	**4.001**	**6.162**
300	3016.575	**1.370**	**2.068**	**4.802**	**7.396**
350	3519.3375	**1.598**	**2.413**	**5.603**	**8.629**
400	4022.1	**1.827**	**2.758**	**6.403**	**9.863**
450	4524.8625	**2.055**	**3.103**	**7.203**	**11.094**
500	5027.625	**2.283**	**3.448**	**8.004**	**12.347**
550	5530.3875	**2.512**	**3.793**	**8.805**	**13.561**
600	6033.15	**2.740**	**4.138**	**9.605**	**14.794**

Table 4. Solution of a/h=20 and a/b=1,0.8 shell element deformations

		Deformation (mm)	
Depth (m)	*Hydrostatic pressure (kPa)*	*a/h=20 a/b=1*	*a/h=20 a/b=0.8*
100	1005.525	**4.009**	**6.369**
150	1508.2875	**6.015**	**9.557**
200	2011.05	**8.022**	**12.745**
250	2513.8125	**10.025**	**15.927**
300	3016.575	**12.031**	**19.115**
350	3519.3375	**14.038**	**22.303**
400	4022.1	**16.045**	**25.491**
450	4524.8625	**18.047**	**28.673**
500	5027.625	**20.054**	**31.861**
550	5530.3875	**22.060**	**35.049**
600	6033.15	**24.067**	**38.237**

These results are for isotropic doubly curved shell element. Now in the following table we have a cylindrical shell element deformation results.

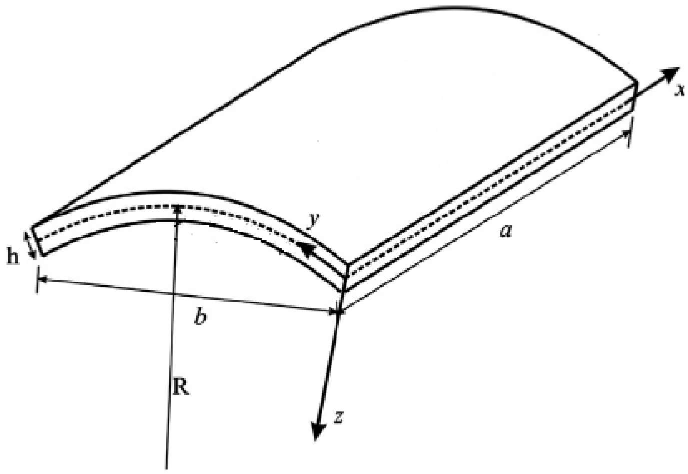

Figure 3. A cylindrical shell element

Table 5. Solution of a/h=10-a/b=1,0.8 and a/h=15-a/b=1,0.8 cylindrical shell element deformations

		Deformation(mm)			
Depth (m)	*Hydrostatic presure (kPa)*	*a/h=10 a/b=1*	*a/h=10 a/b=0.8*	*a/h=15 a/b=1*	*a/h=15 a/b=0.8*
100	1005.525	**1.608**	**1.608**	**5.427**	**5.429**
150	1508.2875	**2.413**	**2.413**	**8.144**	**8.146**
200	2011.05	**3.218**	**3.219**	**10.860**	**10.864**
250	2513.8125	**4.021**	**4.022**	**13.572**	**13.579**
300	3016.575	**4.826**	**4.827**	**16.288**	**16.294**
350	3519.3375	**5.631**	**5.632**	**19.005**	**19.013**
400	4022.1	**6.436**	**6.438**	**21.721**	**21.729**
450	4524.8625	**7.239**	**7.241**	**24.432**	**24.441**
500	5027.625	**8.044**	**8.046**	**27.149**	**27.158**
550	5530.3875	**8.849**	**8.852**	**29.866**	**29.876**
600	6033.15	**9.654**	**9.657**	**32.582**	**32.593**

5. PERMITTED STRESSES

Submarine design criterion Türk Loydu Part E Chapter 111-Naval Ship Technology, Submarines (2007) gives the permitted stresses on submarine hull. According to Türk Loydu rules, permitted stresses can be found with following instructions.

$\frac{R_{m,20}}{A^1}$ and $\frac{R_{eH,t}}{B^1}$ $R_{m,20}$ is maximum tensile strength [N/mm^2], $R_{eH,t}$ is yield point or %0.2 proof stress [N/mm^2]. A^1 and B^1 are safety coefficients[6]. The lower one is used for permitted stresses.

For HY-100 steel [6], [7];

$R_{m,20}$=820 MPa

$R_{eH,t}$=690 MPa

A^1=2.7

B^1=1.7

$$\frac{R_{m.20}}{A^1} = 303.7MPa$$

Permitted stress=303.7 MPa

$$\frac{R_{eH,t}}{B^1} = 405.8MPa$$

We need to determine the maximum stresses on each depth. Determined maximum stresses for three different length-thickness ratio are in the following table.

Table 6. Maximum stresses accordint to a/h=10,15,20

		Maxiumum stresses (MPa)		
Depth (m)	*Hydrostatic pressure (kPa)*	*a/h=10*	*a/h=15*	*a/h=20*
100	1005.525	**22.61**	**66.79**	**187.56**
150	1508.2875	**33.93**	**100.09**	**281.44**
200	2011.05	**45.25**	**133.48**	**375.23**
250	2513.8125	**56.54**	**166.80**	**469.51**
300	3016.575	**67.67**	**200.18**	**564.21**
350	3519.3375	**78.81**	**233.57**	**658.42**
400	4022.1	**89.12**	**266.96**	**752.76**
450	4524.8625	**91.56**	**300.28**	**844.33**
500	5027.625	**113.11**	**333.65**	**938.80**
550	5530.3875	**124.32**	**366.92**	**1033.12**
600	6033.15	**135.74**	**400.44**	**1126.29**

It can be seen in foregoing table;

- For a/h=10; 303.7 MPa permitted stress value is not exceeded,
- For a/h=15; at 500m, 550m and 600m depths permitted stress is exceeded.
- For a/h=20; after 150m depth permitted stress is exceeded.

6. CONCULUSION AND RECOMMENDATIONS

In this paper submersed submarine shell deformation has been investigated due to hydrostatic pressure. Deformation analysis are made for isotropic doubly curved and cylindrical shell element. Neglecting lame parameters derivatives in numerical solution facilitated problem and neglecting did not influence the result that seen at numerical solution and FEM analysis comparison. In relation to deformation investigation of doubly curved shell element, emerging stress components in our problem compared with permitted stresses in Türk Loydu Rules. About this comparison, different exceeding occurred at different length-thickness ratio of shell element that tells us the importance of determination thickness of the shell.

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