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STRUCTURAL INTEGRITY ASSESSMENT OF EXISTING PLATFORMS

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ABSTRACT

In the coming years several existing offshore platforms in Indonesia will be required to be re-certified due to (a) having exceeded the design life and (b) change in the original certified condition. Most of these will continue to be operational, hence re-certification will become mandatory due to Migas regulations. These platforms will pose a real risk to life and environment. Further they will be operating without proper insurance coverage.

For re-certification, these platforms need to satisfy a re-assessment procedure. The structural integrity studies form an integral part of such assessments. In most cases the traditional "elastic " methods will be inadequate for the structural integrity studies of existing platforms. Currently it is widely recognized that if an existing structure does not meet the "elastic design" criteria it does not mean that the structure is inadequate or unserviceable. In recent years the need to go beyond the elastic limits for such analysis has been accepted. A number of research projects and studies have emerged to address this problem. Of these the most important document was the American Petroleum Association (API RP2A-WSD sect 17.0) draft code. This code recommends the use of Full Plastic Collapse Analysis (FPCA) also known as "push over" analysis for the strength integrity studies of the existing platforms.

Though this technique has been known for a number of years, universally very few platforms have been re-assessed using the FPCA method. This method was adopted two years ago by YPF-Maxus Southeast Sumatra Inc (MAXUS) on the structural integrity assessments of a number of existing platforms. Resources required to carry out such studies are currently available in Indonesia.

The objective of this paper is to describe the FPCA method, and the methodology that is adopted for such assessments. The paper will also present case studies from MAXUS project, and will conclude by interpreting the results obtained.

INTRODUCTION

In Indonesia there are a number of offshore platforms which have exceeded, or which are coming close to the end of their design life. A number of these platforms are still operational, and will continue to do so producing oil and/ or gas economically. It is also seen that due to the current economic climate some operators wish to increase the productivity of certain platforms. To achieve this increase in production these particular platforms need to be enhanced with additional facilities on deck, conductors and risers outboard. In both these cases the relevant platforms need to be re-assessed for their structural integrity.

These studies are mandatory, for the re-certification by third parties, which is a requirement by Migas and moreover for renewing insurance.

In the assessment process many factors have to be taken into consideration, such as life safety, environmental impact, strength, fatigue life, risk, etc. Most of these topics are well discussed and documented. In recent years the strength criteria, or the structural integrity of platforms has been a "hot" topic as the traditional methods used to carry out

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strength studies for existing platforms have been found to be inadequate.

The traditional elastic method (on which the current codes are based) designs a member to its elastic limit with a "built in" factor of safety. Currently it is a widely recognized fact that if an existing structure does not meet the "elastic design" based criteria, it does not mean that the structure is inadequate or unserviceable. In recent years the need for the re-assessment of existing platforms going beyond the "elastic limit" has been recognised. A number of research projects and papers have emerged, most importantly a draft code by the American Petroleum Association namely API RP2A-WSD Sect 17.0 (API).

This API draft code gives guidelines for the re-assessment process addressing a number of issues associated with such studies. For strength analysis it recommends the ultimate (Push Over) analysis to ascertain the intact or "as built" capacity or strength of a platform. In recent years (approximately 3 years) this method has been adopted in limited projects. Most probably the reason for this is that resources to carry out such studies are not readily available. In 1997 for the first time in Indonesia the FPCA method was adopted by YPF Maxus Southeast Sumatra Inc (MAXUS) on the structural integrity studies of a number of existing platforms.

The objectives of this paper are to describe the FPCA method, the analytical techniques adopted, structural and load modelling to be used for such studies. The paper will also present typical results and their interpretation. These objectives will be achieved by presenting "case studies" of the platforms analysed for the MAXUS project.

ASSESSMENT PROCESS

The philosophy adopted for the assessment of the "MAXUS" platforms is briefly described in this section. Detailed methodology and narrative for major activities are also described.

The assessment process as described in API is based on the Gulf of Mexico environment. The critical environmental design criteria as described in API are hurricanes and winter storms. As the environment is less severe in the South China Sea, the API recommended criteria and data for such assessments are not applicable for Indonesia. As there are no recommendations nor guidelines for local conditions it was decided to adopt the API document for guidance, but to use engineering judgement to choose applicable data and coefficients for the study.

Please refer to Figure 1 for flow chart for the sequence of major activities related to structural integrity studies carried out.

Data Collation

All available data on the particular platforms were collected, reviewed and documented. During this stage sufficient information had to be collected to allow an engineering assessment of the platform's overall structural integrity. It was ensured that any assumptions made were reasonable, and the information gathered were both accurate and representative of actual conditions prevailing at the time of the study. The documents considered included the following:

1. As-built drawings
2. Survey reports
3. Design reports
4. Soil reports
5. Environmental Studies
6. Technical reports

etc

In most cases site visits were arranged to verify equipment layout, weights, and to check for any deck variations.

Categorization and Rating of Platform

The assessment procedure for existing platforms separates the life safety and environmental issues, and applies criteria that depend upon location and consequence.

Life safety exposure categories are related to the safety of personnel located on platforms, the logistics and the related time for safe evacuation in case of damage. Life safety categories are:

1. Manned, Non-Evacuated
2. Manned Evacuated
3. Unmanned

Environmental issues are related to liquid hydrocarbon and or sour gas release in the case of the collapse of the platform and the damage caused. It is related to the location of the platform and the environment that it is exposed to. Environmental impact categories are:

1. Significant Environmental Impact
2. Insignificant Environmental Impact.

Platforms must be assessed in accordance with the applicable exposure category and corresponding assessment criteria. At this stage platforms have to be rated. This rating has to be in the form of a factor of safety against collapse taking into consideration the Life Safety and the Environmental impact.

The Load Factors for platform rating were derived as follows :

$R (Rs/Fs, Rf/Ff) > Fd \times D + Fe \times E)$

Where :

R = Ultimate platform strength

Rs = Non-linear structural strength

Rf = Non-linear foundation strength

D = Non-environmental load

E = Environmental load

Fd = Load factor on non-environmental load = 1.0

Fe = Load factor on environmental loads

= 1.15 for unmanned platforms not used for oil or gas storage

= 1.30 for all other platforms

Fs = Material factor for structure = 1.15

Ff = Material factor for foundation = 1.30

Rewriting the inequality above, we have

$R (Rs, Fs/Ff \times Rf) > Fd \times Fs \times D + Fe \times Fs \times E$

Substituting the factors, the inequality will reduce to :
$R (Rs, f/1.13) > 1.5 \times D + 1.32 \times E$ for unmanned platform not used for oil or gas storage.

or $1.15 \times D + 1.50 \times E$ for all other platforms.

Compile Design Basis

Once all the data pertaining to the platform had been collected, checked and verified, a design basis was compiled. Design basis includes the following:

1. System description and design life
2. Applicable codes, standards, specifications and statutory requirements.
3. Dead and Live loading
4. Environmental loading, directions and impact criteria.
5. Soil data
6. Structural analysis criteria.
7. Acceptance criteria
   etc.

The design basis was approved by the company before the commencement of the study.

Structural Analysis

According to API to establish structural integrity, a platform may be evaluated on three levels of increasing complexity. These three levels are:
1. Screening Analysis
2. Elastic Analysis
3. Full Plastic Collapse Analysis

The Screening analysis is the simplest and most conservative check. This method is generally used by certifying authorities. As this propriety information, data, and software were not available this method could not be adopted. The other two methods were used in the project and are described in the following sections.

Compilation of structural model

It was decided to use the Structural Analysis Computer System (SACS) for the computer simulation. Based on the design criteria and colleted data a space frame finite element computer model for the platform was compiled. The model included the jacket, piles and soil, representative super structure, all appurtenances and all applicable loads. The model was compiled accurately in accordance with relevant standards and codes. Strict quality control procedure was implemented to check the computer model.

Jacket integrity

Once the structural model is validated, the study follows two (2) paths as follows:
1. Strength Analysis
2. Joint checks for Fatigue Life

Please note that the Fatigue Life study, and Risk assessment is excluded from this paper. These, being complex problems, will be addressed in a separate publication.

Elastic analysis

For the assessment of existing structures it is desirable to commence with the traditional elastic method. The reasons for these are the following:
1) With the results obtained from elastic analysis the model can be accurately verified with results of previous analysis.
2) The results will give a good indication of how the structure is behaving.
3) Any errors and/or discrepancies can be easily detected at this stage and necessary remedial measures taken.

For the analysis carried out it was decided to use the LRFD method. The results from the analysis were critically investigated. Checks were carried for any member overstress. i.e unity check (UC) greater than 1.0. If there were no over-stressed members the analysis was concluded with the platform passing the structural integrity.

If there were overstressed members these were checked to establish whether they are primary or secondary members and their location in the platform. Remedial engineering was undertaken to "strengthen", or to introduce new members to change the load path, so as to reduce the indiced stresses in overstressed members. The platform was reanalysed incorporating these modifications and if the members satisfied the code check the structure was considered to have passed the assessment. If the platform still failed the code check, the next stage (FPCA) was evoked.

Full plastic collapse analysis (FPCA)

FPCA was carried out on the platform for 16 wave action directions. From the results the following information was extracted.

1. Load Factors at Collapse.
2. Load factors when the platform becomes unserviceable.
3. The critical members.

From the above results a stress contour of the RSR values at collapse, and at unserviceable points was compiled. The critical RSR values was compared with the acceptable RSR value as established at the categorization and platform rating stage (Sec 2.2). If the RSR value is acceptable the platform is considered to have passed the assessment.

If the RSR value is below the required value it will be assessed with the platform rating. Here a decision has to be taken after carrying out a Risk assessment. If the risk is acceptable remedial action will be postponed, but the platform will be monitored according to a schedule and criteria drawn up.

If the risk is unacceptable the platform will be examined for remedial action and the necessary engineering will be formulated. FPCA will be carried out on the amended structure and the critical RSR value so obtained will be checked as before. If it is acceptable the platform will be considered to have passed the assessment.

If the revised Risk assessment is not satisfactory the platform will be certified as unserviceable and necessary remedial actions will be recommended.

Observations

From the analysis carried out on a number of "MAXUS" platforms it was noted that a large number did not satisfy the "Elastic Analysis" condition. In these cases the integrity study had to be extended to the third (3) stage i.e FPCA.

FULL PLASTIC COLLAPSE ANALYSIS

FPCA also known as "push over" analysis reduces conservatism and attempts to provide the ultimate capacity of the platform. FPCA establishes the Reserve Strength Ratio (RSR) of the platform. RSR is to quantify the amount of reserve strength in a platform at failure in relation to that of its current status.

FPCA mode of assessment of existing platforms offers an improved design concept over the traditional

Elastic method. The Elastic mode of design is based on the allowable stress criteria. The FPCA method of assessment shows that a platform has adequate strength to withstand the applied loads with local overstress and damage, but without collapse. This method is useful for the analysis of platforms subjected to static and quasi static environmental loads.

Concept of FPCA

In a structure when a location in a member reaches its ultimate stress levels it behaves in-elastically. This in-elastic behaviour of members stressed past yield and or buckled members reduces strength and stiffness of the structure thereby causing redistribution of the loads to the adjacent members. This redistribution of loading is conceptualized in the FPCA method. The FPCA can be described in this manner:

1) Initially the actual loading on the platform is applied.
2) These loads are then discretely increased in load steps.
3) At the end of each load step the member locations stressed past yield, and the buckled members are remodeled with non elastic properties.
4) This load increment, and remodeling for non elastic behaviour is continued until the structural stiffness has reduced to a level where the platform will "collapse".
5) The FPCA keeps a track of the behaviour of the structure as force level is increased until it reaches the extreme load when it reaches the "Collapse" stage.

Features of The Computer Program Used

For the study SACS Collapse program (COLLAPSE) was used. The COLLAPSE program uses a unique solution procedure that uses a large deflection, interactive, tangent direct stiffness solution technique to solve for geometric and material non-linearities associated with the ultimate load capacity of the structure. The program facilities can be briefly described as follows:

Members

Member elements are divided by default into eight (8) sub segments. Each sub segment is treated as a separate member for stiffness calculations. The complete member is treated as a super element.

Member cross sections are represented by sub areas depending on section type. For example, tubular cross sections are divided into twelve (12) sub-areas or arc lengths. Each sub-area is checked for plasticity using Von Mises stress during each solution iteration which allows the gradual plastification of the member cross section. Permanent set and strain hardening are checked for each sub-area after plasticity occurs. When all sub-areas of cross section become fully plastic, a temporary hinge is introduced at the particular location in the member. The strain history is recorded for each sub-area which allows the member element to retain plastic deformation and residual stress. Local buckling of the member cross section is calculated empirically and is treated as a permanent hinge. Connection capacity exceedence at a joint is calculated empirically and a permanent hinge is placed at that location.

An iterative large deflection solution is completed for each member to generate the member elemental stiffness. During the solution iteration process for the stiffness of the member the sub-segment properties are modified due to plasticity, local buckling etc along the length and through the cross section. Also the end stiffness are modified due to connection plasticity or failure. Member buckling is an intrinsic part of the member large deflection solution.

Tubular connection flexibility is modelled empirically using Efthymiou formulas. The modeling is achieved by inserting a set of elastic springs between the member ends and the connecting nodes enabling the calculation of the member/connection rotational failure. This failure mode is based on the Marshall and Gates procedure. When such a failure is detected the particular member stiffness is deleted from the overall stiffness matrix. Connection that have yielded are modeled as a permanent hinge and is calculated using API-LRFD ultimate strength formulas.

Plates

Flat plate elements are divided into five (5) sub-layers through the thickness. Each sub-layer is treated as a separate plate for stiffness calculations and the complete plate is treated as a superelement. Plate buckling and snap through is considered in large deflection finite element mesh solution. Also the strain history of each sub-layer is recorded which allows the plate element to retain plastic deformation residual stress.

Pile/soil

Soil data is considered as lateral P-Y curves, axial T-Z curves and end bearing Q-Z curves. Soil properties can vary with pile penetration. The pile is represented as a set of segmented members. A large deflection beam-column supported on non-linear springs analysis is carried out. Pile plasticity and hinges are calculated using the same methods described in the section on "Members". The effective stiffness is calculated at the pilehead and this is incorporated to the platform stiffness for each solution iteration of the entire structure.

Full Plastic Collapse Analysis Procedure

FPCA procedure can be briefly described as follows:

1) After validifying the platform structural model select the "collapse" loads to be applied. The applicable loads will be the vertical loading representing all dead and super loads and the 100 year current and wave action representing the lateral loading.
2) For the first (1) load step, apply 100% the vertical and the lateral loading.
3) Maintaining the lateral loading, increase the vertical loading by 15% in appropriate load steps.
4) Maintain the vertical loading and increase the lateral load in suitable steps till the platform reaches "collapse"
5) Record the RSR value for the analysis for the particular wave action direction
6) Repeat steps 1 through 5 for sixteen (16) wave attack directions.
7) Compile a contour of RSR values for the sixteen (16) wave attack directions
8) From the contour identify the minimum RSR value, which will be the RSR value for the platform and the wave attack direction for this minimum value will be the critical environmental action direction.

Full Plastic Collapse Analysis Solution Procedure

The SACS computer program uses a double level iteration solution procedure to account for elemental and global non-linearities. The following is a description of the solution procedure as used within the program.

Initial solution

For the initial solution, 100% vertical and lateral loading following procedure will be adopted:

1) All structural elements are assumed to be linear.
2) Pile stiffness is based on zero lateral displacement and rotation.
3) Deflections are calculated for all nodes.

Iterative solution

For all subsequent solution iterations the following procedure is used.

1) Member stresses and nodal deflections from the previous global solution are used as the boundary conditions for the non-linear member stiffness solution of the current iteration.
2) Local stiffness of beams and plates and the conditions are altered as described in the sections on "Members", "Plates", and "Pile/Soil".
3) A global solution is performed, and the new deflections are calculated for all nodes.
4) In the iterative solution steps 2 and 3 are repeated until the convergence requirements are met and equilibrium conditions are satisfied.
5) The next load condition is applied and a global solution is performed repeating steps 1 through 4.
6) Step 5 is repeated until one of the conditions is met.
   a). All load increments are complete.
   b). User specified global maximum deflection is exceeded.
   c). Excessive deflection due to global collapse of the structure.

The complete incremental history of the structure displacements, loads, plasticity, buckling, connection failure etc are retained for all elements for printing, or for post processing into graphical form.

MAXUS PROJECT

MAXUS has current plans to enhance oil/gas production with minimum capital investment. As a part of this program MAXUS intends to drill additional wells on a number of their existing wellhead production platforms. These additional conductors/wells and the associated facilities will induce increased dead/live and environmental loads on the platforms. It becomes necessary to check the structural integrity of these platforms so that they are safe to carry out normal production operations during the intended period of their service life.

Platforms Re-assessed

A number of platforms were re-assessed to check their structural integrity. The list of platforms studied are shown in Table 1.0. When deck inspections were carried out, in some cases the "as-it-is-status" of the deck did not confirm to the as-built drawings. The descripinancies were on the form of:

1. Additional equipment and piping
2. Deck extensions
3. Additional conductors and risers
4. Relocation of equipment and risers

Results

General

Up to date 24 platforms has been re-assessed. The analysis carried out were as follows:

No of Platforms	Type of Analysis		
	Elastic	Elastic + FPCA	FPCA
24	12	2	12

The general observations are as follows:

1. Of the platforms which passed the elastic criteria a number showed member overstress. The over stressed members were located on the decks and on the top brace level of the jacket. The "overstress" conditions were overcome either by strengthening the critical members, or by introducing additional members.

2. Where FPCA was necessary, generally the super structure was stable and "collapse" occurred on the piles above and below ground level. We have identified that this is a general phenomenon in this region.

Intan-B platform results

The structural model adopted for the analysis is shown in Figure 2. The complete platform (jacket and topsides) were modelled, including the proposed additional conductors. PCA generally relates to the jacket. Hence to simplify the FPCA it was decided to split the model in to two (2) sections, namely the Deck and the Jacket with common joints at the transition (stabbing) points. The jacket model was modified to include the deck stiffness at various levels with equivalent members.

An elastic analysis was carried out for the dead and live loads for the deck. The resultant reactions at the transition points were introduced to the jacket for FPCA analysis.

The results of the FPCA analysis are shown in Figure 3 and Figure 4. The Figure 3 shows the collapse mode of the structure. The plate 1 shows the critical jacket members. It is seen that most of the "collapsed" members occurred at the "walkway" level of the jacket. These members were in the conductor frame and are not critical to cause jacket collapse.

The plate 2 and 3 shows the pile status above and below the mudline respectively. It shows the piles at the mud level have gone plastic causing the platform to collapse.

The plate 4 shows the non-linear behaviour of a pile head.

The Figure 4 shows the stress contour for the platform. The RSR value for serviceability, and collapse for sixteen (16) wave attack directions were plotted. This plot shows that although the platform shows RSR values are over 2.0 at collapse, values for serviceability are reduced. The serviceability limit state is due to the deck deformation.

From the collapse contour it is seen that:

1) The critical wave attack direction is 0.0 degrees for serviceability RSR value of 1.35.
2) The critical wave attack direction is 70.0 and 90.0 degrees for collapse RSR value of 2.10.

By checking against a collapse RSR value of 1.5 for this platform rating it was concluded that the platform can safely accommodate 4 addition 20" diameter conductors.

CONCLUSIONS

From the MAXUS study it can be concluded that FPCA offers a viable method for the reserve strength studies of existing platforms. There RSR studies forms an integral part in the strength re-assessment leading up to the re-certification of existing platforms.

The FPCA results were consistent with the critical "elastic" analysis carried out which generally shows the piles being the most stressed elements in the platforms.

The SACS COLLAPSE program was recently benchmarked against two other (2) similar leading programs. The test was carried out by Bomel in London where an X-braced space frame was tested to destruction by applying incremental horizontal forces. From the published data it was concluded that the SACS COLLAPSE program gave very favourable results.

Recommendations

For a study of this nature to be successful the necessary conditions are:

1) Accurate data acquisition
2) Produce reliable design basis
3) Compile accurate structural model. FPCA being a very sensitive analysis the answers are as good as the structural model adopted.
4) An experienced engineer is mandatory for the successful running of the analysis and the interpretation of the results. FPCA uses a non-linear large deflection iterative process. On most cases the execution of the problem need to be interrupted to check for the results to satisfy the convergence criteria.

From the experience gathered on the MAXUS project it can be concluded that the FPCA method can be effectively used as a part of the existing platform re-certification process. Currently in Indonesia there are no guidelines nor recommendations for the use of this method nor for the re-certification process. It is recommended that MIGAS produce a document with guidelines for such studies.

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TITLE : STRUCTURAL INTEGRITY EVALUATION
FOR CERTIFICATION OF EXITING
OFFSHORE JACKETS

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REV 0
DATE : JUNE, 1999
CHECKED BY : Retno
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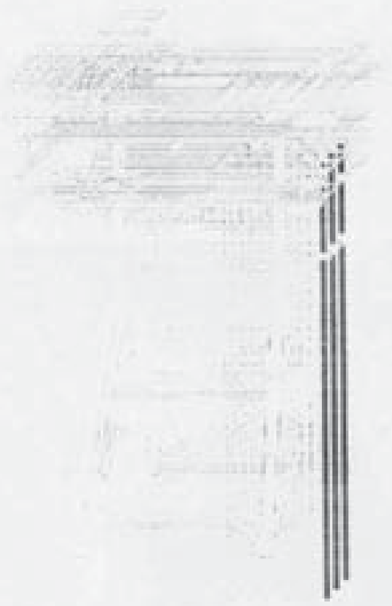

Exiting Conductors

▇ Proposed additional Conductors

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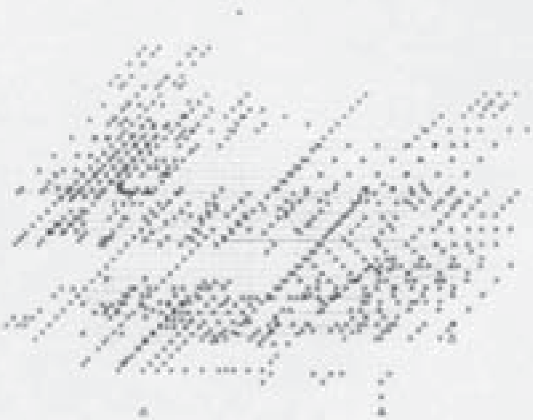
[illegible] MODEL



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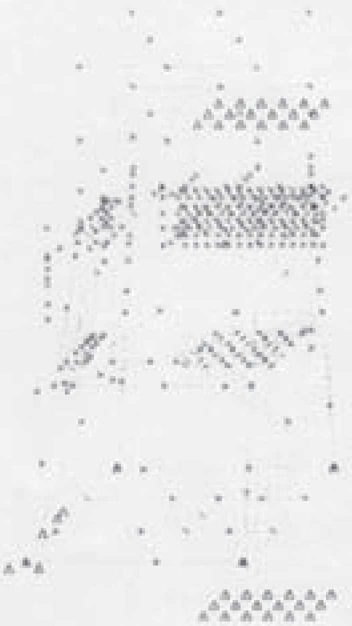

JACKET COMPUTER MODEL

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TITLE :
INTAN 'B' PLATFORM MODEL

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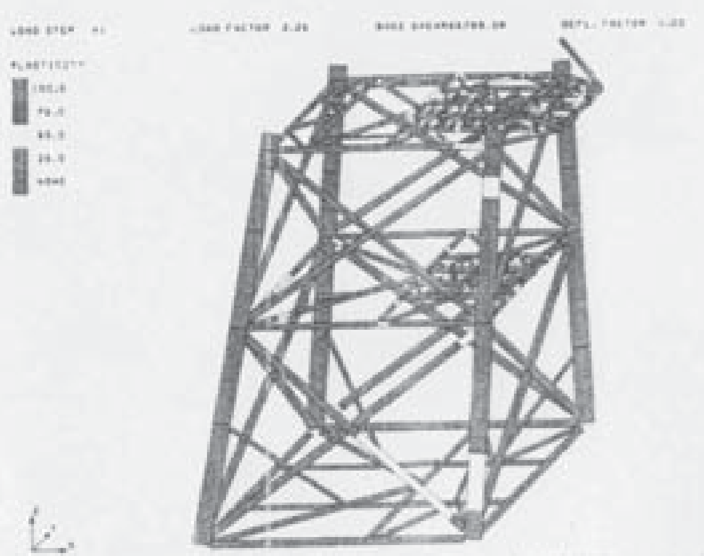
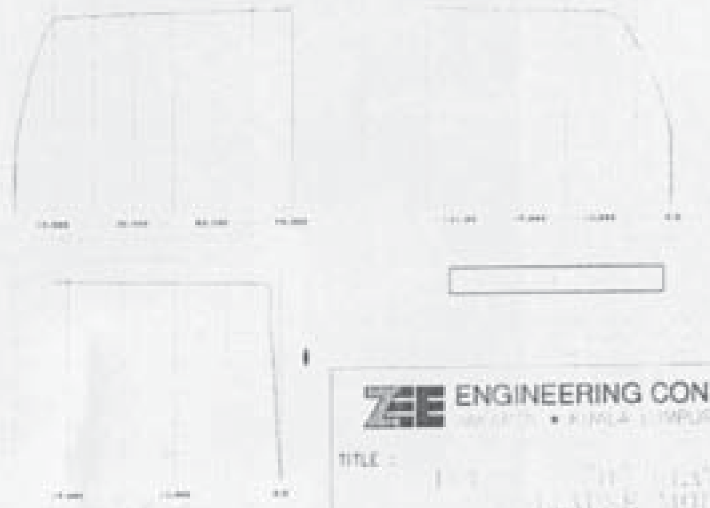


JACKET - CRITICAL MEMBER

PILES ABOVE MUDLINE
CRITICAL MEMBER

PILE BELOW MUDLINE
CRITICAL MEMBER



TYPICAL PILE-SOIL
JOINT DETAILS

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TITLE : [illegible] PLATFORM
COLLAPSE MODE

SCALE NTS
DATE : JUNE, 1999
SK- No : SK-4.02
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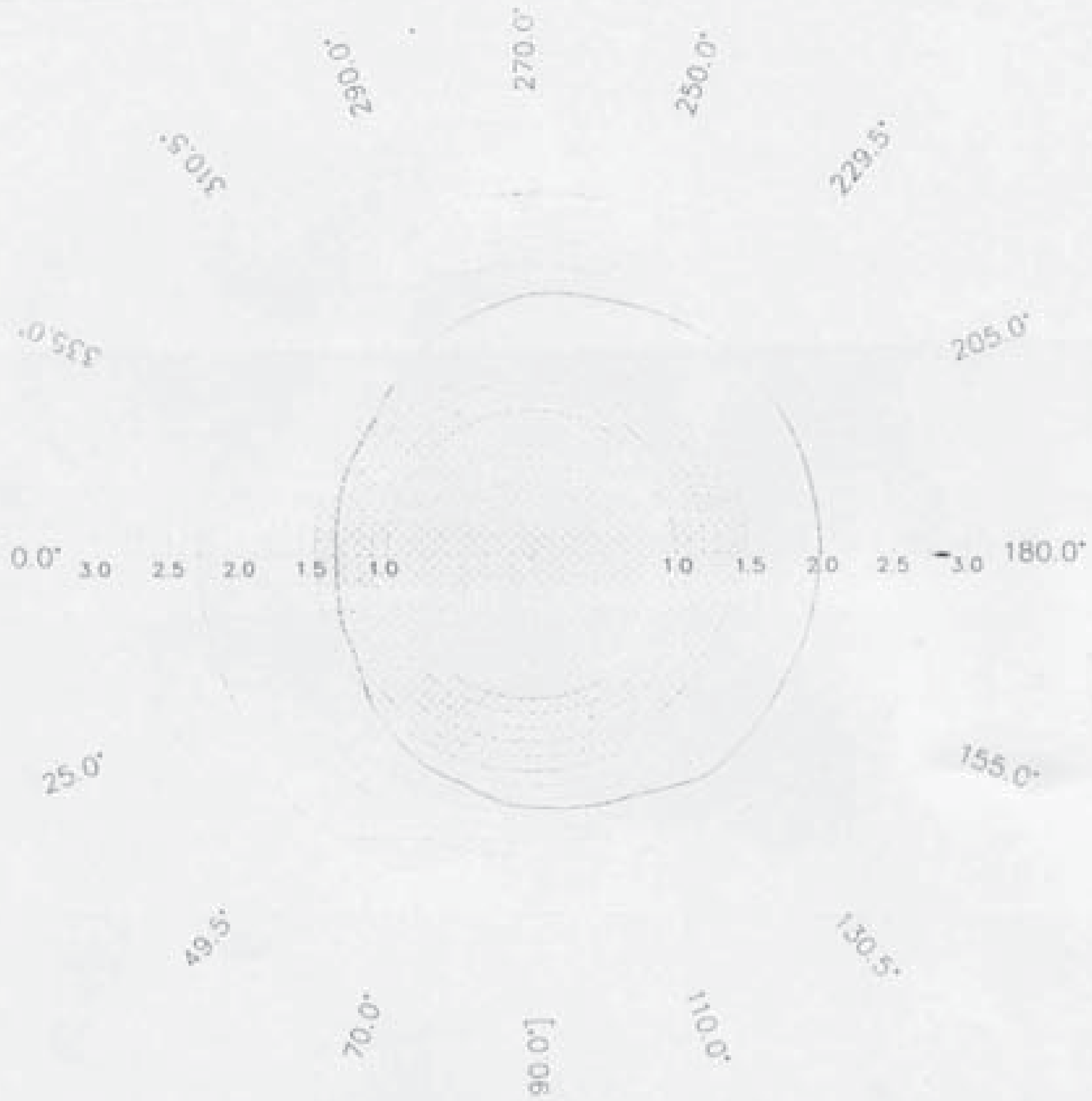
SK402.DWG



ENVIRONMENTAL DIRECTION	R.S.R VALUE	
	SERVICEABILITY	COLLAPSE
0.0°	1.35	2.30
25.0°	1.40	2.30
49.5°	1.55	2.40
70.0°	1.65	2.10
90.0°	1.75	2.10
110.0°	1.80	2.20
130.5°	1.95	2.30
155.0°	1.95	2.70
180.0°	2.00	2.75
205.0°	2.00	2.70
229.5°	1.95	2.75
250.0°	1.85	2.55
270.0°	1.80	2.50
290.0°	1.65	2.35
310.5°	1.50	2.35
335.0°	1.40	2.25

MINIMUM ACCEPTABLE RSR VALUE = 1.5 FOR COLLAPSE

NOTE :

BELOW ACCEPTABLE LIMIT

R.S.R @ COLLAPSE

— R.S.R @ SERVICEABILITY

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TITLE :
INTAN – [illegible] COLLAPSE CONTOUR

SCALE :	NTS	DRAWN By :	IGN	REV
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TABLE 1

TABULATION OF PLATFORM ANALYSED

Table 4.0 **Tabulation of platform analysed**

No.	Name of Platform	Location	Activity	Age (yr)	Water Depth (ft)	Type	Type of Analysis		Remarks
							Elast.	FPCA	
1	SUNDARI-A	106° 12' 51.917" E 4° 59' 53.046" S	Wellhead platform	18	73	4 legged	Yes	-	For additional 3 nos 20" conductors. OK
2	CINTA-B	106° 15' 17.482" E 5° 27' 0.327" S	Wellhead platform	29	113	4 legged	Yes	-	For Ideco Work Over Rig Deck members needed re-design
3	KODECO JUNCTION PLATFORM	9 241 551 m N 716 941 m E	Wellhead platform		54	3 legged	Yes	-	For Ideco Work Over Rig Deck members needed re-design
4	KODECO SATELLITE PLATFORM		Wellhead platform		63	3 legged	Yes	-	For Ideco Work Over Rig Deck members needed re-design
5	SELATAN-B	106° 11' 34.780" E 5° 34' 52.460" S	Wellhead platform	21	162	4 legged	Yes	-	For additional 3 nos 20" conductors Not recommended
6	KRISNA-10	106° 13' 4.11" E 5° 11' 04.22" S	Wellhead platform	18	84	3 legged	Yes	-	For Ideco Work Over Rig Deck members needed re-design
7	RAMA-E	106° 20' 0.610" E 5° 25' 13.530" S	Wellhead platform	21	116.0	4 legged	Yes	-	For additional 3 nos 20" conductors Not recommended
8	FARIDA-A	106° 19' 44.44" E 5° 10' 51.97" S	Wellhead platform	18	79	4 legged	-	Yes	For additional 3 nos 20" conductors. Recommended 2 nos 20" conductors
9	FARIDA-B	106° 18' 41.910" E 5° 10' 36.63" S	Wellhead platform	18	89	4 legged	-	Yes	For additional 3 nos 20" conductors. Recommended 2 nos 20" conductors
10	FARIDA-C	106° 17' 32.080" E 5° 10' 36.610" S	Wellhead platform	16	96	4 legged	-	Yes	For additional 3 nos 20" conductors. Recommended 2 nos 20" conductors

No.	Name of Platform	Location	Activity	Age (yr)	Water Depth (ft)	Type	Type of Analysis		Remarks
							Elast.	FPCA	
11	INDRI-A	106° 35' 55.365" E 4° 38' 46.787" S	Wellhead platform	8	70	4 legged	-	Yes	For additional 3 nos 20" conductors Recommended 2 nos 20" conductors
12	INTAN-B	106° 39' 37.626" E 4° 34' 48.060" S	Wellhead platform	10	68	4 legged	-	Yes	For additional 4 nos 20" conductors. OK
13	TITI-A	106° 24' 13.209" E 5° 10' 13.354" S	Wellhead platform	18	72	4 legged	-	Yes	For additional 3 nos 20" conductors. OK
14	RAMA-F	106° 20' 17.87" E 5° 27' 08.54" S	Wellhead platform	18	107	4 legged	yes	-	For additional 4 nos 20" conductors. OK
15	ZELDA-C	106° 21' 12.940" E 5° 11' 7.350" S	Wellhead platform	19	78	4 legged	-	-	For additional 3 nos 20" conductors. OK
16	ZELDA-A	106° 22' 56.435" E 5° 11' 10.667" S	Wellhead platform	26	74	4 legged	-	Yes	For additional 3 nos 20" conductors. OK
17	ZELDA-D	106° 22' 10.590" E 5° 10' 12.870" S	Wellhead platform	19	76	4 legged	-	Yes	For additional 3 nos 20" conductors. OK
18	ZELDA-E	106° 22' 0.930" E 5° 11' 21.900" S	Wellhead platform	18	76	4 legged	-	Yes	For additional 3 nos 20" conductors. OK
19	WIDURI-A	106° 37' 44.387" E 4° 40' 1.069 " S	Wellhead platform	10	68.58	4 legged	Yes	Yes	For additional 5 nos 20" conductors. Recommended 3 nos 20" conductors
20	WIDURI-B	106° 37' 54.961" E 4° 41' 1.487" S	Wellhead platform	10	69.5	4 legged	-	Yes	For additional 5 nos 20" conductors. Recommended 3 nos 20" conductors

No.	Name of Platform	Location	Activity	Age (yr)	Water Depth (ft)	Type	Type of Analysis		Remarks
							Elast.	FPCA	
21	WIDURI-D	106° 36' 36.246" E 4° 40' 51.204" S	Wellhead platform	10	70.708	4 legged	Yes	Yes	For additional 5 nos 20" conductors. Not recommended
22	INTAN-A	106° 35' 55.06" E 4° 35' 04.73" S	Wellhead platform	9	71.5	4 legged	Yes	-	For additional 4 nos 20" conductor. OK
23	KARMILA-A	106° 31' 57.68" E 4° 59' 14.39" S	Wellhead platform	17	69.0	4 legged	Yes	-	Inplace Check OK
24	WIDURI-P	106° 37' 46.518" E 4° 40' 1.618" S	Process platform	4	68.84	8 legged	Yes	-	For additional deck equipment and deck vibration study. OK