ملخص

فـي هـذا البحـث تـم تطـوير برنـامج حاسـوب (NUSAP) بطريقـة العناصـر المحـددة لتحليـل المنشآت الوحية (مسائل الإجهاد/الانفعال المستوي). المعرضة للأحمال الاستاتيكة.

تم ربط النظام بمعالجين مرنين: لإدخال البيانات (معالج الإدخال) ولعرض المخرجات (معالج الإخـراج) اللـذين أعـدا خصيصـاً لهـذه الدراسـة وذلـك لتـوفير طريقـة سـهلة لإدخـال البيانـات للبرنامج عن طريق قوائم تحاور مباشر وقوالب إدخـال، ولعـرض المخرجـات للمستخدم بيانياً وفي شكل جداول مصاغة بطريقة سلسة.

في هذه الدراسة تم التركيز علي التحليل الخطي والتحليل اللاخطي للمنشآت الغشـائية المستوية (مسائل الإجهاد/الانفعال المستوي) تم استخدام عنصـر ذو أربـع عقد (QPM4) وعنصـر ذو ثمان عقد (QPM8).

تـم تطـوير التقنين اللاخطـي هندسياً (بنـاءً علـي تقنين لاقرانج الكلـي) باستخدام انفعـال قـرين (GNGRS) والانفعـال الهندسـي (GNGES) والانفعـال اللـوغريثمي (GNLGS) وطبقـت هذه الصيغ في برنامج الحاسوب (NUSAP). تم حل مجموعة المعادلات اللاخطية باستخدام طريقة نيوتن- رابسون

تم التحقق من دقة نتائج البرنامج باستخدام أمثلـة عدديـة حيث أظهـرت النتـائج المتحصـل عليهـا موافقة مع النتائج المنشورة في عدة أوراق علمية.

وتم الحصول علي الاجهادات الناتجة من التحليل الاخطي من الصيغ المختلفـة للانفعـال وتـأكيد دقتها بمقارنتها مع النتائج المنشورة.

ومن ثم تم الحصول علي الاجهاد الحقيقـي المرافق للانفعـال اللـوغريثمي وذلـك لأحمـال تـؤدي إلي إزاحات كبيرة جدا.

ABSTRACT

In this research, a general-purpose finite element system (NUSAP) is developed for the analysis of plate structures (plane stress/strain problems) subjected to static loading.

The program is linked to two processors: Pre-Processor, developed specially to supply the program with the necessary data through an inter-active menu and dialogue boxes, and Post-processor for presenting the out put results in formatted sense.

This study focused on the linear and nonlinear analysis of plane stress/strain structures using 4-node (QPM4) and 8-node (QPM8) plane stress/strain elements.

A geometric nonlinear formulation based on the total Lagaregian formulation and using Green's strain (GNGRS), geometric strains (Engineering strains) (GNEGS) and Logarithmic strains (GNLGS) was adopted. The formulations were implemented into the nonlinear finite element program (NUSAP). The solution of nonlinear equations was obtained by the Newton-Raphson method.

The accuracy of the results of the formulation is demonstrated by using four numerical examples and the results are in agreement with other available published solutions.

The non-linear stresses from the different strain formulations were obtained. A comparison was made between the obtained strains and published results

The true stress associated with the logarithmic strain was thus obtained for loads that result in very large displacements.

TABLE OF CONTENTS

CHAPTER THREE: Nonlinear Finite Element Method

CHAPTER FOUR: General Description of the Program

CHAPTER FIVE: The Pre-processor and Post-processor Interface

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

$\boldsymbol{a}$	Set of discretization parameters
$\boldsymbol{a}_n$	converged solution at a previous load level or time step
$\boldsymbol{a}$	vector of nodal displacements
$\boldsymbol{A}$	matrix containing displacements derivatives w.r.t. Cartesian displacements
$\boldsymbol{B}_o$	matrix contains shape function derivatives w.r.t ξ, η, ζ
$\boldsymbol{B}_L$	matrix of nonlinear displacement components
$\boldsymbol{D}$	Elastic matrix
$\boldsymbol{E}$	young's modulus
$\boldsymbol{g}_{x,}\boldsymbol{g}_y$	displacement gradient vector
$\boldsymbol{G}$	matrix containing shape function derivatives
G	shear modulus
$\boldsymbol{h}$	thickness
$\boldsymbol{i}, \boldsymbol{j}, \boldsymbol{k}$	unit vectors in direction of global coordinates
$\boldsymbol{j}$	jacobian matrix
$\boldsymbol{K}$	stiffness matrices
$\boldsymbol{K}_T$	tangent stiffness matrix due to green strains
$\boldsymbol{K}_\sigma$	additional geometric stiffness matrix
$\boldsymbol{K}_\sigma^*$	additional geometric stiffness matrix (geometric strains)
K_σ^{**}	additional geometric stiffness matrix (logarithmic strains)

$\boldsymbol{K}_{GT}^{*}$	tangent stiffness matrix due to geometric strains
$\boldsymbol{K}_{TL}^{*}$	tangent stiffness matrix due to logarithmic strains
$\boldsymbol{l},\boldsymbol{m},\boldsymbol{n}$	components of unit vectors (direction cosines)
$\boldsymbol{M}$	additional initial stress matrix
$\boldsymbol{N}_i$	shape function at node i
$\boldsymbol{P}$	additional initial
$\boldsymbol{r},\boldsymbol{s},\boldsymbol{t}$	natural coordinates
$\boldsymbol{T}$	transformation matrix
$\boldsymbol{u}$	nodal displacement vector
$\boldsymbol{u},\boldsymbol{v},\boldsymbol{w}$	displacement in global Cartesian coordinates
$\boldsymbol{X},\boldsymbol{Y},\boldsymbol{Z}$	global Cartesian coordinates
$\boldsymbol{\theta}$	vector containing displacement's derivatives w.r.t. Cartesian coordinates
$\boldsymbol{\sigma}$	2nd piola - kirchhoff stress vector
$\boldsymbol{\sigma}_1^{'},\boldsymbol{\sigma}_2^{'}$	vector containing engineering stress
Ψ	residual forces
γ_{xz},γ_{yz}	green strains (shear component)
$\gamma_{xz}^{'},\gamma_{yz}^{'}$	geometric strains (shear component)
$\boldsymbol{\delta\varepsilon},\boldsymbol{\delta A},..$,etc.	variation of ε,….etc.
α_i,β_i	nodal rotation
$\gamma^{'}.\gamma$	shear angle
ξ,η,ζ	element curvilinear
$\varepsilon_{x},\varepsilon_{y}$ **and** γ_{xy}	green strains
$\varepsilon^{'}_{x},\varepsilon^{'}_{y}$ **and** $\gamma^{'}_{xy}$	geometric strains
$\varepsilon_{xlx},\varepsilon_{ylx}$ and γ_{xylx}	logarithmic strains

LIST OF ABBREVIATIONS

CBF	**C**onstant **B**ody **F**orce
CL	**C**oncentrated **L**oad
DLNORM	Limit of **D**isp**L**acement **Norm**
GNGRS	**G**eometric **N**onlinear **G**reen's **S**train
GNGES	**G**eometric **N**onlinear **G**eometric **S**train
GNLGS	**G**eometric **N**onlinear **L**ogarithmic **S**train
INCOUT	**INC**rement interval for **OUT**put of results
ISOFLEX	**ISO**tropic **FLEX**ural Element
MAR	Limit of **M**aximum **A**bsolute **R**esidual (RMAXAL)
NALPS	Maximum no. of conjugate Newton iteration
NIT	Maximum **N**o. of **IT**eration for each load increment
NITOUT	**N**o. of **IT**eration interval for **OUT**put of results
NRIT	Maximum no. of **N**ewton- **R**aphson **IT**eration
NUSAP	**NU**ha **S**tructural **A**nalysis **P**rogram
QAX4	**Q**uadrilateral **AX**i-symmetric element with **4** node
QAX8	**Q**uadrilateral **AX**i-symmetric element with **8** node
QF4	**Q**uadrilateral plate **F**lexural element with **4** nodes
QF8	**Q**uadrilateral plate **F**lexural element with **8** nodes
QF9	**Q**uadrilateral plate **F**lexural element with **9** nodes
QPM4	**Q**uadrilateral **P**lane **M**embrane element with **4** nodes
QPM8	**Q**uadrilateral **P**lane **M**embrane element with **8** nodes
QPM9	**Q**uadrilateral **P**lane **M**embrane element with **9** nodes
RLNORM	limit of **R**esidual **NORM**

RMS	Limit for **R**oot **M**ean **S**quare of residual (RNORAL)
TAX3	**T**riangular **AX**i-symmetric element with **3** nodes
TAX6	**T**riangular **AX**i-symmetric element with **6** nodes
TF3	**T**riangular Plate **F**lexural element with **3** nodes
TF6	**T**riangular **P**late **F**lexural element with **6** nodes
TPM3	**T**riangular **P**lane **M**embrane element with **3** nodes
TPM6	**T**riangular **P**lane **M**embrane element with **6** nodes
UDL	**U**niformly **D**istributed **L**oad