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# INDHOLD

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The series R (Report ISSN 0108-0768), in which the research reports are being published may be obtained in subscription. The subscription price outside Denmark, covering publications in the period 1st July 1991 to 30th June 1992, is Dkr. 130,-. Payment should accompany orders of subscription.

A publication exchange agreement may be made with institutions working with structural research problems. Please apply for further information.

AGERSKOV, HENNING: *Fatigue Strength of Welded Lap Plate Connec-
     tions. (Udmattelsesstyrken af svejste laskeplade samlin-
     ger). International Institute of Welding, Annual Assembly,
     Montreal, July, 1990, IIW Doc. XIII-1350-90, 17 pp. (Re-
     prints available).

*The fatigue strength of welded single and double lap plate con-
nections has been studied. Eight series of tests have been carri-
ed out, varying the main dimensions of the test specimens.

   In the tests performed, the fatigue cracks initiated either in
the main plate or in the lap plate - at the edge of the trans-
verse weld or at the end of the longitudinal weld. For the double
lap plate joints, the test results showed a higher fatigue
strength for a failure initiating at the edge of the transverse
weld than for a failure initiating at the end of the longitudinal
weld.

   Furthermore, the effect of preloading on the fatigue strength
was studied. The test results clearly demonstrated that preload-
ing generally will have a beneficial effect with respect to fa-
tigue, due to the reduction in the level of tensile residual
stresses and/or the introduction of compressive residual stresses
at the critical points.

AGERSKOV, H., se også YAMADA K. og HENNING AGERSKOV

ASKEGAARD, V., L.O. NIELSEN and S. WICHE: *Measurement of contact
     stresses on a thin silo wall. Proc. 9th Intern. Conf. on
     Experimental Mechanics, Copenhagen. August 20-24, 1990, p.
     59-66.

*Measurements of normal- and shear contact stresses are of inter-
est in thin walled silos. Because the pressure cell thickness no
longer is small compared with silo wall thickness and may also
have a different stiffness, the stress distribution on the cell
may deviate from what would have been the case had the silo wall

been undisturbed. This may lead to a measuring error. In the pa-
per an estimate is given of this measuring error by using FEM
methods. A technique is also described where a small part of a 5
mm thick steel silo wall has been cut out, transformed into a
two-component pressure cell and reinstalled in the wall with very
little change of the local stiffness. Equilibrium tests have been
carried out in a steel model-silo with 14 such cells.

   The calculated results indicate that to obtain a relative mea-
suring error of less than 5% in a model silo with Epoxy wall the
stiffness of the pressure cell should not deviate more than 20%
from the stiffness of the Epoxy. The use of a pressure cell of
metal would lead to excessive errors when used in shells of rela-
tively low stiffness. It also follows that the thickness of the
cell and the wall must deviate only a few percent.

   For a steel silo model the thickness ratio between cell and
wall should be less than 1.25 to obtain a relative error less
than 5%, i.e. a total thickness of the inclusion of 6-7 mm in a 5
mm thick wall.

   For a full scale steel silo the thicknesses should deviate less
than 5% to obtain a measuring error lower than 5%.


BRØNDUM-NIELSEN, TROELS: *Redistribution of Concrete Stresses due
      to Creep after Change of Structural System. (Spændingsom-
      lejring i betonkonstruktion på grund af krybning efter æn-
      dring af det statiske system). ACI Structural Journal. V.
      87, No. 4, July-August, 1990, pp. 393-396. (Reprints avail-
      able).


*Changes in the structural system may create drastic concrete
stress redistributions due to creep (relaxation), a fact which is
frequently ignored. After the change of the structural system,
the stress redistribution caused by the load transferred to the
first structural system changes towards a disribution close to
that which would have existed if the load had been transferred
after the change of the structural system.

Ændringer af betonkonstruktioners statiske system kan medføre drastiske spændingsomlejringer på grund af betonens krybning (relaksation). Dette forhold overses ofte. Efter ændring af det statiske system vil spændingsfordelingen fremkaldt af lasten overført til det oprindelige statiske system omlejres, så spændingsfordelingen nærmer sig stærkt til den, der ville optræde, hvis lasten havde været påført efter ændringen af det statiske system.

BRØNDUM-NIELSEN, TROELS: *International Research Cooperation. (Internationalt Forskningssamarbejde). Proceedings XXII International Conference of Young Scientists in the Field of Concrete and Reinforced Concrete, Irkutsk, USSR. V. III, May 1990, pp. 10-13 (English version) and pp. 11-14 (Russian version). (Reprints available).

*The need of international research cooperation is emphasized. Economic problems and language barriers exist. Methods of overcoming such obstacles and for establishing international contacts between researchers are suggested.

Behovet for internationalt forskningssamarbejde påpeges. Økonomiske problemer og sprogbarrierer er alvorlige hindringer. Der anføres metoder til at klare disse vanskeligheder og til at etablere international kontakt mellem forskere.

BYSKOV, ESBEN: *Selected Buckling Problems. Dr. Techn. Thesis. (Udvalgte Stabilitetsproblemer. Teknisk Doktorafhandling). Afdelingen for Bærende Konstruktioner, DTH., vi + 49 s., 1989.

*Three major aspects of buckling in the presence of geometric imperfections are studied: Elastic buckling with mode interaction, Plastic buckling without mode interaction, and Plastic buckling with mode interaction with main emphasis on the first subject.
    Equally important are two subjects closely connected with

above: Investigations of the range of applicability of the asymptotic expansion developed by Byskov & Hutchinson, and Numerical determination of buckling and postbuckling quantities.

I afhandlingen studeres tre emner, som er vigtige for forståelsen af bulingsfænomener, der domineres af geometriske imperfektioner, nemlig: Elastisk buling med 'mode interaction', plastick buling uden mode interaction samt plastisk buling med mode interaction, idet vægten lægges på det første emne.

Der studeres også to andre emner, der er lige så vigtige, og som er nøje knyttet til ovenstående, nemlig: Gyldighedsområdet for den asymptotiske udvikling, der først er opstillet af Byskov & Hutchinson samt numerisk bestemmelse af forskellige størrelser, der er knyttet til buling og 'postbuckling'.

## BYSKOV, ESBEN, se også STANG, H., M. TONNESEN og E. BYSKOV

## DAHL, KAARE K.B.: *Preliminary state-of-the-art report on multiaxial strength of concrete. (Foreløbig 'state-of-the-art' rapport om betons fleraksede styrke). Afdelingen for Bærende Konstruktioner. Serie R, nr. 262, 1990. 77 s. Gratis.

*This report deals with the strength of concrete subjected to triaxial stress fields.

The report describes some of the more important failure criteria for concrete. Furthermore, a description of the possible factors that affect, or are thought to affect, the triaxial strength of concrete is included. Also in the report is a description of the various test arrangements used through the years. These test arrangements all have strengths and weaknesses which are described. Finally, most of the published strength results are presented, along with a bibliography over the published research.

Denne rapport omhandler styrken af beton udsat for en treakset spændingstilstand.

Rapporten gennemgår kort en række af de mere vigtige brudbetin-
gelser for beton, og sammenligner disse brudbetingelser med opnå-
ede forsøgsresultater. Ydermere gennemgås en lang række af fakto-
rer, der har indflydelse på - eller menes at have indflydelse på
- bæreevnen af beton over for treakset spændingstilstand.

Rapporten indeholder også en gennemgang af de vigtigste
forsøgsopstillinger og -legemer, der er blevet brugt igennem
tiderne, idet der fokuseres på fordele og ulemper ved de
pågældende forsøgsmetoder.

Sluttelig præsenteres de fleste af de til dato publicerede for-
søgsresultater, sammen med en bibliografi over emnet 'treakset
spændingstilstand i beton'.


DAMKILDE, LARS: Elementmetoden for bjælkekonstruktioner. (*The
    Finite Element Method for Frame Structures. In Danish). Af-
    delingen for Bærende Konstruktioner. Serie F, nr. 118,
    1990. 85 s. Kr. 20,- excl. moms.


Formålet med notatet er at bibringe de studerende en grundlæggen-
de forståelse for elementmetoden. Metoden er søgt fremstillet bå-
de som en systematisk formulering og videreudvikling af den tra-
ditionelle deformationsmetode til brug ved håndregning, og som et
værktøj til udvikling af beregningsmetoder for egentlige 2- eller
3-dimensionale legemer som f.eks. skiver og plader.

Notatet omhandler kun plane rammer, og der gennemgås både den
statiske løsning og beregning af den klassiske stabilitetslast.
Ved beregning af stabilitetslasten benyttes tilnærmede formfunk-
tioner, og dette forhold bruges til generelt at diskutere valg af
elementinddeling, som har stor betydning ved anvendelse i f.eks.
skive- og pladeproblemer.


*The aim of the text is to give a fundamental understanding of
the finite element method. The method is presented both as a sys-
tematic and refined development of the classical deformation
method and as a tool for analysis of 2- and 3-dimensional struc-
tures e.g. slabs and plates.

The text only considers plane frames, and we regard both static
load and calculation of the classical critical load. For the sta-
bility problem we apply approximate shape functions, and this in-
troduces a general discussion of the choice of element size,
which is of very great importance in e.g. plate and shell struc-
tures.


DAMKILDE, LARS, se også KRENK, STEEN OG LARS DAMKILDE


DITLEVSEN, OVE: *Asymptotic First-Passage Time Distributions in
     Compound Poisson Processes. Structural Safety, No. 8, 1990,
     pp. 327-336. (Reprints available).

*First-passage problems for compound Poisson processes appear in
reliability investigations concerning damage accumulation in
structures that are subject to random process excitations. Asymp-
totic first-passage time distributions are easily obtained. Their
accuracies are studied by use of simulation. Surprisingly good
accuracy is achieved.


DITLEVSEN, OVE, R.E. MELCHERS and H. GLUVER: *General Multi-Di-
     mensional Probability Integration by Directional Simula-
     tion. Computers & Structures, Vol. 36, No. 2, 1990, pp.
     355-368. (Reprints available).

*$n$-Dimensional integration by Monte Carlo directional importance
sampling using analytical or numerical integration for each simu-
lated direction is discussed. A suitable general class of sam-
pling distributions is considered. The class is denoted as the
class of mixed $\bar{\mu}$-centred standard Gaussian and $D$-truncated $\bar{\mu}$-cen-
tred standard Gaussian distributions, where $\bar{\mu}$ is a position vec-
tor and $D$ is a pragmatically chosen subset of $R^n$.
   The relative efficiency of different choices of the sampling

distribution from the class is studied by way of examples for probability integration in particular. In addition, the same integrals are formulated in different variable representations by the substitution method before the directional Monte Carlo integration is carried out.

Moreover, it is demonstrated how sensitivities of the integrals with respect to parameter variations or integration boundary variations can be obtained during the same Monte Carlo simulation primarily set up for obtaining the integral.

The novelty compared with previous reports on the topic of integration in the standard Gaussian space is the demonstration that the combination of simulation and numerical integration can be applied for general integrals without any significant change of efficiency.


DITLEVSEN, OVE og HENRIK O. MADSEN: Bærende Konstruktioners Sikkerhed. (*Structural Reliability Methods. In Danish). SBI-rapport 211, 1990, 480 sider. /%/.

Bærende konstruktioners sikkerhed varetages i dag ved partialkoefficientnormer, der forudsætter "sædvanlige" konstruktioner underkastet "sædvanlig" statisk analyse. Kan sædvanlig statisk analyse med tilhørende formelle sikkerhedsregler uden anfægtelser erstattes af regneprogrammer for avanceret analyse? Hvad gør man, når konstruktionen er usædvanlig? Hvad med eksisterende konstruktioner? Bogen behandler den probabilistiske filosofi og metodik for sikkerhedsanalyse, og det klargøres, at også denne kræver normgivne regler. Ud over at være tænkt som lærebog henvender bogen sig til projekterende ingeniører og normskrivere.

*Structural safety is in current practice most often ensured by partial coefficient codes (or similar types of codes) that are assumed to be valid with the provision that the structures are "usual", and that these structures are analysed by "usual" static analysis. Can usual static analysis with associated formal rules of safety assessment without trouble be replaced by computer pro-

grams for advanced analysis? What to do if the structure is unusual? What about existing structures? The book introduces the probabilistic philosophy and methodology for structural reliability analysis, and it is made clear that this type of analysis also requires code given rules. Besides being a text book for students, the book is addressed to designing engineers and code writers.

DITLEVSEN, O., se også HASOFER, A.M., O. DITLEVSEN OG R. OLESEN

DYRBYE, C: *Time-Domain Dynamic Analysis of Structures Subjected to Seismic Actions. (Dynamisk analyse i tids-domænet af konstruktioner udsat for seismiske påvirkninger). Proc. 9 EAEE Congress, Moskva 1990, vol. 7-A, pp. 161-166.

*The paper describes results of calculation of bending moments in a 3-storey frame subjected to different realisations of ground acceleration. There is a rather large scatter in the results, especially when the duration is short. In a realisation, a minor increase in the duration may give rise to a remarkable increase in the maximum response values, even if they have been constant for, say 10 seconds.

The results indicate that the number of simulated earthquakes should be selected such that responses corresponding to characteristic values could be introduced.

I artiklen beskrives resultater af beregninger af bøjningsmomenter i en 3-etages ramme udsat for forskellige realisationer af grundens accelerationer. Resultaterne viser ret stor spredning, især hvis varigheden er kort. Ved en realisation kan en mindre forøgelse af varigheden give anledning til en væsentlig øgning af maksimum responsværdier, selv om de eksempelvis har været konstante gennem 10 sekunder.

Resultaterne indikerer, at antallet af simulerede jordskælv bør vælges, så der kan bestemmes karakteristiske værdier af respon-

set.

FEDDERSEN, B: Jernbetonbjælkers bæreevne - rene og kombinerede
    påvirkninger. (*Load-Bearing Capacity of Reinforced Con-
    crete Beams - Pure and Combined Actions. In Danish). Afde-
    lingen for Bærende Konstruktioner. Serie R, nr. 251, 1990.
    259 s. Gratis. /Lic/.

Denne rapport beskæftiger sig med jernbetonbjælkers bæreevne un-
der kombinerede snitkræfter.

Som teoretisk udgangspunkt anvendes teorien for idealplastiske
materialer.

Indledningsvis berøres i rapporten grundlaget for anvendelse af
plasticitetsteorien ved brudberegning af beton og jernbeton. End-
videre repeteres de generelle flydebetingelser og armeringsform-
ler for isotropt armeret beton, da disse i udstrakt grad anvendes
i den resterende del af rapporten.

I de efterfølgende kapitler behandles ren bøjning, bøjning med
normalkraft, forskydning, ren vridning, kombineret forskydning,
vridning og bøjning og endelig i sidste kapitel berøres andre
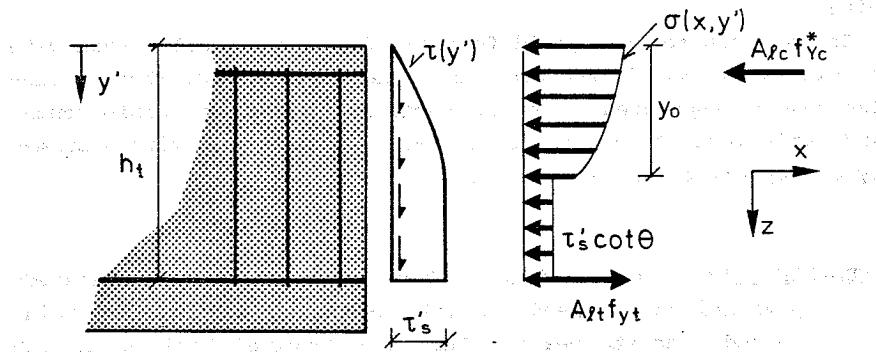kombinationer af snitkræfterne.

I hvert kapitel opstilles for en bjælke med rektangulært tvær-
snit og en simpel snitkraftfordeling udtryk til bestemmelse af
bæreevnen. Denne model udstrækkes derefter til vilkårlige tvær-
snit, armeringsudformninger og snitkraftvariationer. Hvert kapi-
tel afsluttes med en dimensioneringsanvisning.


*This report deals with the problem of calculation of the ulti-
mate strength of beams loaded in combined actions.

The theory of plasticity is used as a theoretical model.

By way of introduction the report is touching on the basis for
using the theory of plasticity to solve ultimate strength pro-
blems within the field of concrete and reinforced concrete. Fur-
thermore, the yield conditions and the reinforcement design for-
mulas for isotropic reinfored concrete are dealt with, these for-
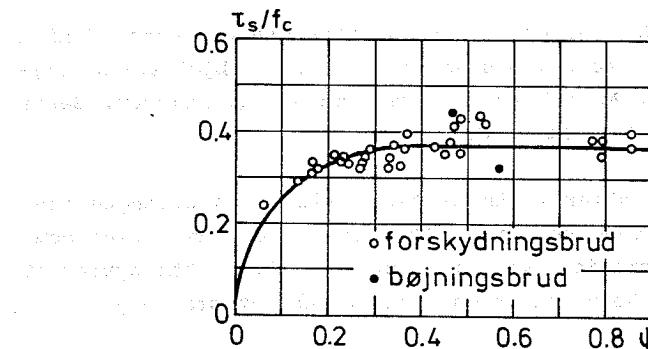mulas being used extensively in the remaining part of the report.

Tilladelig spændingsfordeling.
*Permissible stress distribution.



Teori sammenlignet med forsøg.
*Comparison between theory and tests.
Ref.: FEDDERSEN, BENT: Jernbetonbjælkers bæreevne – rene og kom-
binerede påvirkninger. (s. 14).

In the following chapters bending, bending with normal force, shear, torsion, combined torsion and bending, combined shear, torsion and bending and finally other combinations are dealt with.

In each chapter the yield formulas for a rectangular beam with simple variations in the section forces is examined. These formulas are extrapolated to other sections, types of reinforcement and variations of section forces. Each chapter ends with a summary of appropriate design rules.

FEDDERSEN, B: Jernbetonbjælkers Bæreevne - rene og kombinerede
        påvirkninger. Appendiks. (*Load-Bearing Capacity of Rein-
        forced Concrete beams - Pure and Combined Actions. Appen-
        dix. In Danish). Afdelingen for Bærende Konstruktioner. Se-
        rie R, nr. 252, 1990. 122 sider. Gratis.

Se B. Feddersen, Jernbetonbjælkers Bæreevne - rene og kombinerede
påvirkninger. Serie R, nr. 251.

GANWEI, CHEN and M.P. NIELSEN:   *Shear Strength of Beams of High
        Strength Concrete. (Forskydningsstyrke af bjælker af høj-
        styrkebeton). Afdelingen for Bærende Konstruktioner. Serie
        R, nr. 258, 1990. 16 s. Gratis.

*Several groups of shear tests of beams with high strength con-
crete, which are found so far in the literature, have been com-
pared with the theoretical solutions of beam shear. The agreement
between tests and theory has been found to be satisfactory.

Adskillige grupper af forskydningsforsøg med bjælker udført af
højstyrkebeton fundet i litteraturen er blevet sammenlignet med
teoretiske løsninger. Overensstemmelse mellem forsøg og teori er
fundet tilfredsstillende.

GANWEI, CHEN, M.P. NIELSEN and K. JANOS: *Ultimate load carrying
    capacity of unbonded prestressed reinforced concrete beams.
    (Bæreevne af bjælker med ikke injicerede kabler). Afdelin-
    gen for Bærende Konstruktioner. Serie R, nr. 259, 1990. 25
    s. Gratis.

*In this report the plastic theory for reinforced concrete struc-
tures is investigated in relation to beams with unbonded tendons.
   Concerning the bending resistance of beams with unbonded ten-
dons, it has been found previously that the stress at failure in
the prestressing bars is often lower than in corresponding beams
with bonded tendons. This is confirmed by the plastic analysis
and according to this, the phenomenon is due to the fact that the
transition from the normally reinforced case to the overrein-
forced case takes place at a depth of the compression zone which
is only about half the value of a corresponding beam with bonded
tendons.
   The shear resistance of beams with unbonded tendons can be
treated by the plastic theory if in some cases the value of the
effectiveness factor is put at a lower value than for beams with
bonded tendons.

I denne afhandling undersøges anvendelsen af plasticitetsteorien
på forspændte bjælker med ikke injicerede kabler.
   Det er tidligere fundet, at man ved bøjningsundersøgelser ikke
kan opnå udnyttelse af spændarmeringen i samme grad som ved for-
spændte bjælker med injicerede kabler. Dette bekræftes af den
teoretiske undersøgelse efter den plasticitetsteoretiske model,
og det skyldes, at trykzonehøjden ved overgang til overarmeret
tværsnit kun er ca. halvt så stor som ved bøjning af bjælker med
injicerede kabler.
   Forskydningsbæreevnen af bjælker med ikke-injicerede kabler er
ligeledes undersøgt på basis af plasticitetsteorien. Det viser
sig, at de sædvanlige udtryk kan bruges, når blot den effektive
plastiske trykstyrke undertiden regnes lidt lavere.

GANWEI, CHEN and M.P. NIELSEN: *A short note on plastic shear
     solutions of reinforced concrete columns. (Notat vedr. pla-
     stisk forskydningsstyrke af søjler). Afdelingen for Bærende
     Konstruktioner. Serie R, nr. 260, 1990. 17 s. Gratis.

*In this report solutions for the shear capacity of reinforced
beams and columns subjected to bending, shear and compression are
described. The solutions are based on the theory of plasticity.

I dette notat beskrives løsninger for forskydningsbæreevnen af
bjælker og søjler af armeret beton påvirket til bøjning, forskyd-
ning og tryk. Løsningerne er baseret på plasticitetsteorien.


GANWEI, CHEN, se også OLSEN, DAVID HOLKMANN, CHEN GANWEI og M.P.
NIELSEN


GLUVER, H.: *One Step Markov Model for Extremes of Gaussian Pro-
     cesses. (Ét-trins Markov Model for Ekstremerne af Gaussiske
     Processer). Serie R, nr. 261, 1990. 40 s. Gratis.

*A Markov model for simulation of the successive extremes of a
stationary Gaussian process is developed. The model is based on
an approximate joint density for the consecutive extremes, and
its applicability is limited to processes with mono peak power
spectra of limited bandwidth. The approximate joint density is
calculated and discussed for a narrow-band and a broad-band pro-
cess. An unexpected singular behaviour of the joint density for
small ranges is observed and verified by analytical means. A sim-
ple discretization technique appropriate for practical applica-
tion of the Markov model is discussed, and the simulation scheme
is briefly outlined.

I rapporten udvikles en Markov model til simulering af følgen af
ekstremer for en stationær gaussisk proces. Grundlaget for model-
len er en approximation til den to-dimensionelle sandsynligheds-

tæthed af 70 på hinanden følgende ekstremer. Den introducerede approximation begrænser modellen til processer med smalbåndet frekvensindhold. Den approximative tæthed beregnes og diskuteres for en smalbåndet og en bredbåndet proces. En uventet singularitet af tætheden for små afstande imellem 70 følgende ekstremer observeres og kan verificeres analytisk. Der foreslås en diskretisering af modellen til praktiske formål, og simulering med den udviklede model gennemgås.

GLUVER, H., se også DITLEVSEN, OVE, R.E. MELCHERS og H. GLUVER

HASOFER, A.M., O. DITLEVSEN and R. OLESEN,:   *Vector outcrossing probabilities by Monte Carlo. Probabilistic Engineering Mechanics, Vol. 5, No. 3, 1990, pp. 122-128. (Reprints available).

*An exact method for calculating the probability that a vectorvalued Gaussian stationary process will cross out of a safe set in a given time, is presented. It is based on representing the process by a random trigonometric polynomial and then calculating the probability by directional simulation. Exact bounds for the error can be calculated, giving a predetermined accuracy. A numerical example relating to the response of a structure to wind excitation is given.

JANOS, se GANWEI, CHEN, M.P. NIELSEN og K. JANOS

JOHANNESEN, JOHANNES MORSING, se RIBERHOLT, H. og JOHANNES MORSING JOHANNESEN

JØNSSON, JEPPE: *Recursive Finite Elements for Buckling of Thin-
    Walled Beams. (Rekursiv finite elementmetode for stabilitet
    af tyndvæggede bjælker). Afdelingen for Bærende Konstrukti-
    oner. Serie R, nr. 263, 1990. 204 s. Gratis. /Lic./.

*The methods of fabrication, design and analysis of thin-walled
beams are briefly described in the introduction.

  A continuum mechanical description, by use of variational prin-
ciples, leads to the initial stress problem of buckling and to
the treatment of asymptotic postbuckling.

  The theory of plates and finite plate elements is treated and
problems of plate elements are discussed. By use of variational
principles the treatment leads to the formulation of a new hybrid
displacement element with corrected curvatures and boundary rota-
tions. The corrected boundary rotations are compatible between
elements and the curvatures are improved by removing high order
curvature terms.

  For structures consisting of identical repetitive substructures
a recursive substructuring technique, which takes advantage of
the simple repetition, is described. The structural problem is
solved by a sequence of recursive steps, in which the problem is
transformed into a similar problem involving half the number of
identical substructures. The computational work involved in fac-
torisation therefore only grows logarithmically with an increas-
ing number of substructures. For vector problems the efficiency
of recursive substructuring is improved by decoupling the degrees
of freedom of the substructure into symmetric and antimetric de-
grees of freedom.

  Use of the improved recursive substructuring technique and the
developed hybrid displacement element in the finite element mod-
elling of thin-walled beams leads to an efficient method of anal-
ysis. Examples of global and local distortional buckling are
treated, and results show good agreement with established theory.

Fabrikation, design og analyse af tyndvæggede bjælker beskrives
kort i indledningen.
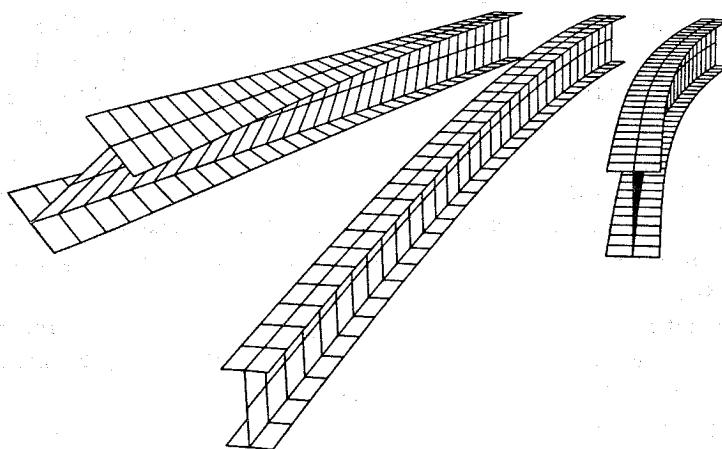
Bulingsformer svarende til bøjning og vridning.
*Flexural and torsional buckling modes.
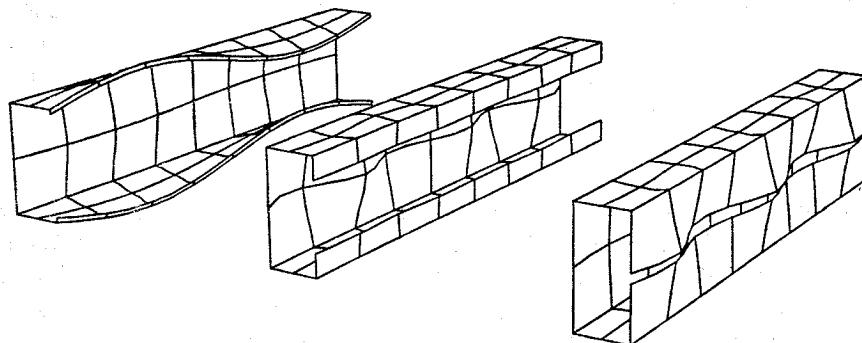


Bulingsformer med tværsnitsdeformationer for U-bjælker.
*Distortional buckling modes for channels.
Ref.: JØNSSON, JEPPE: Recursive finite elements for buckling of
thin-walled beams. (s. 20).

Ved brug af variationsprincipper gives en kontinuummekanisk beskrivelse, som fører til stabilitetsteoriens initialspændingsproblem og til en behandling af asymptotisk efterbulingsteori.

Teorien for plader og finite pladeelementer behandles, og problemer vedrørende pladeelementer diskuteres. Ved brug af variationsprincipper formuleres et nyt hybridt flytningselement med korrigerede krumninger og rotationer på randen. De korrigerede rotationer på randen medfører kompatibilitet elementerne imellem. Krumningerne er korrigerede ved at bortfiltrere krumninger af højere orden.

For konstruktioner, der består af gentagne identiske substrukturer, kan man anvende en rekursiv substruktureringsteknik, som udnytter den simple gentagelse. Det strukturelle problem løses ved brug af en serie rekursive trin. I hvert trin transformeres problemet over i et nyt, som kun indeholder halvt så mange identiske substrukturer. Mængden af beregninger, der skal udføres ved løsningen, vokser derfor kun logaritmisk med antallet af substrukturer. For vektorproblemer øges effektiviteten af rekursiv substrukturering ved at dekoble substrukturernes frihedsgrader i symmetriske og antimetriske frihedsgrader.

Ved at bruge rekursiv substrukturering og det udviklede hybride flytningselement til finite elementmodellering af tyndvæggede bjælker opnås en effektiv analysemetode. Eksempler på global og lokal stabilitetssvigt behandles, og de fundne resultater er i god overensstemmelse med eksisterende teori.


KARLSHØJ, J: Brug af systemplanlægningsværktøjer i byggeteknisk sammenhæng - med udgangspunkt i IDEF-metoderne. (*Application of system planning for the design of structures based on the IDEF-methodology. In Danish). Afdelingen for Bærende Konstruktioner. Serie I, nr. 99, 1990. 51 s.


Rapporten giver en kort oversigt over edb-anvendelserne inden for byggesektoren, og beskriver behovet for at integrere edb-anvendelsen yderligere. Integrationen vil medføre et behov for systemplanlægningsværktøjer eller en anden form for struktureret analy-

se.

Integrationen af de byggetekniske data er vanskelig, da data-
mængderne er store og med komplekse sammenhænge. Anvendelse af
systemplanlægningsværktøjer vil kunne skaffe det fornødne over-
blik, og i rapporten beskrives IDEF-metoderne som et eksempel på
et sådan værktøj.


*The report gives a short overview of the application of comput-
ers within the building sector, and describes the need for inte-
gration between different software applications. The integration
demands use of tools for system planning or some sort of struc-
tured analysis.

Integration of the systems are difficult due to the very large
amount of data with complex internal relations. Application of
system planning will create a better overview, and the report de-
scribes the IDEF-methodology as an example of a tool for system
planning.


KRENCHEL, H. og H. STANG: Cementbaserede Kompositmaterialer.
        (*Cementbased Composite Materials. In Danish). Afdelingen
        for Bærende Konstruktioner. Serie I, nr. 97, 1990. 5 s.+
        appendiks 8 s.

Nærværende skrift er en kort introduktion til og status for
forskning inden for fiberarmerede cementbaserede kompositmateria-
ler og andre højteknologiske cement- og betonmaterialer på Afde-
lingen for Bærende Konstruktioner, Danmarks Tekniske Højskole.
Følgende emner behandles: baggrund for udvikling af nye cement-
baserede materialer, hvorledes øges skøre materialers brudforlæn-
gelse, praktiske anvendelser, fibercement-membraner, status.


*The present paper is a short introduction to and status for the
research in fibre reinforced cementbased composite materials and
other high tech. cements and concretes carried out at the Depart-
ment of Structural Engineering, Technical University of Denmark.
The following subjects are treated: background for the develop-

ment of new cementbased materials, how is it possible to increase
the ultimate tensile elongation of brittle materials, practical
applications, fibre reinforced cement membranes, status.


KRENK, STEEN and LARS DAMKILDE: *Models of Thin-Walled Beam Con-
        nections. Department of Building Technology and Structural
        Engineering, The University of Aalborg, Denmark, Engineer-
        ing Mechanics Papers, R9022, August 1990, 13 pp., presented
        at the IUTAM Symposium on Contact Loading and Local Effects
        in Thin-Walled Plated and Shell Structures, Prague, Septem-
        ber 4-7, 1990. /%/.


*The paper presents the basic ideas for a simple model for con-
nections between thin-walled beams. The coupling between warping
and cross-section distortion at joints is included in a simple
theory. The continuity of the joined flanges and the local cha-
racter of the cross-section distortion permit the distortion de-
formation to be expressed in terms of the warping parameters of
the two beams at the joint. Comparisons have been made with de-
tailed three-dimensional finite element calculations for some
connection types, and the results indicate high accuracy. The
work has later been extended in a more general way to account
more accurately for the different stiffness contributions and
connection types, see the following summary of paper R9038.


KRENK, STEEN and LARS DAMKILDE: *Warping of Joints in I-beam As-
        semblages. Department of Building Technology and Structural
        Engineering, The University of Aalborg, Denmark, Engineer-
        ing Mechanics Papers, R9038, October 1990, 26 pp. /%/.


*A simple theory is developed for the coupled warping and
cross-section distortion at joints between thin-walled I-beams.
Continuity of the joined flanges and the local character of the
cross-section distortion permit the distortion deformation to be
expressed in terms of the warping parameters of the two beams at

the joint. Four types of joints are treated. The unstiffened
joint has two independent warping parameters, the two partially
stiffened joints each have a single warping parameter, while the
fully stiffened joint prevents warping. The distortion mode acts
as a local spring stiffness. The formulation is fully compatible
with classical thin-walled beam theory, and detailed three-dimen-
sional finite element analyses demonstrate high accuracy of the
theory.

LI, Z., se STANG, H., Z. LI og S.P. SHAH

MADSEN, HENRIK O., se DITLEVSEN, OVE og HENRIK O. MADSEN

MELCHERS, R.E., se DITLEVSEN, OVE, R.E. MELCHERS og H. GLUVER

MOBASHER. B., H. STANG and S. P. SHAH: *Microcracking in Fiber
    Reinforced Concrete. (Mikrorevner i Fiberarmeret Beton).
    Cement and Concrete Research, Vol. 20, No. 5, pp. 665-676,
    1990.

*Micromechanisms of matrix fracture in Portland cement based fi-
ber composites are studied by means of quantitative image analy-
sis and acoustic emission techniques. An experimental investiga-
tion has been conducted with different volume concentrations of
polypropylene fibers. Uniaxial tensile specimens were loaded un-
der constant strain rate and the acoustic emission response was
monitored. Thin sectioned epoxy-dye impregnated samples were also
prepared from specimens loaded to specific strain levels. Fluo-
rescence microscopy was used to quantitatively examine the thin
section for crack density, crack length, and crack spacing.

Mikromekanismer forbundet med matrixrevneudbredelse i Portland
cementbaserede fiberkompositter studeres vha. kvantitativ billed-
analyse og akustisk emissions teknikker. En eksperimentel under-
søgelse er udført med polypropylen fibre i forskellige volumen-

25

koncentrationer. Prøvelegemer påvirket til en-akset træk belastedes med konstant tøjningshastighed, og den akustiske emission registreredes. Tyndslib blev fremstillet af fluorescerende epoxy-impregnerede prøvelegemer, som var belastet til forudbestemte tøjningsniveauer. Fluorescensmikroskopi blev benyttet til at kvantificere revnedensiteten, revnelængden og revneafstanden i de betragtede prøvelegemer.

MOBASHER, S., se også STANG, H., B. MOBASHER og S.P. SHAH

NIELSEN, LEIF OTTO: FEM3-prototype på problemgenerelt h-p FEM-program. (*FEM3-prototype on problem general h-p FEM-program. In Danish). Afdelingen for Bærende Konstruktioner. Serie R, nr. 264, 1990, 35 s. Gratis.

Grundlaget for og anvendelsen af et h-p elementmetodeprogram med problemgeneralitet og global adaptivitet er beskrevet.

*The basis and the use of a h-p finite element program with problem generality and global adaptivity is described.

NIELSEN, L.O., se også ASKEGAARD, V., L.O. NIELSEN og S. WICHE

NIELSEN, M.P., se GANWEI, CHEN og M.P. NIELSEN

NIELSEN, M.P., se GANWEI, CHEN, M.P. NIELSEN og K. JANOS

NIELSEN, M.P., se OLSEN, DAVID HOLKMANN, CHEN GANWEI og M.P. NIELSEN

NIELSEN, M.P., se OLSEN, DAVID HOLKMANN og M.P. NIELSEN

OLESEN, R., se HASOFER, A.M., O. DITLEVSEN og R. OLESEN
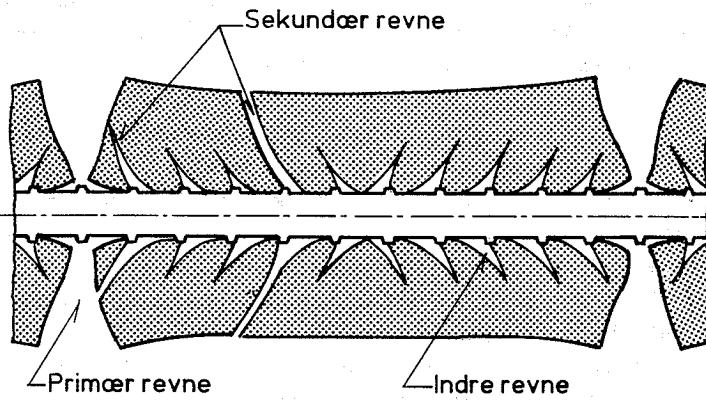
Primære og sekundære revner.
*Primary and secondary cracks.
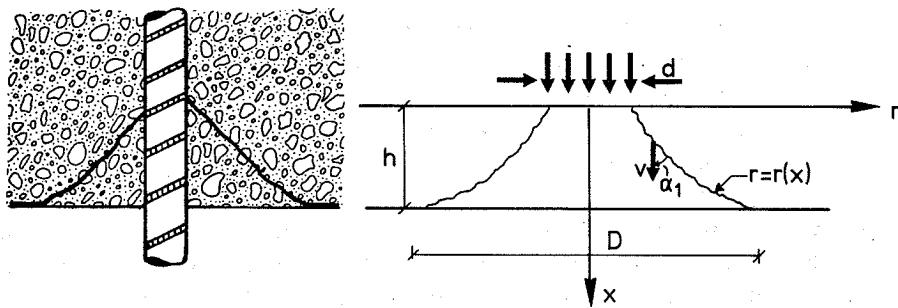


Det revnede betonlegeme med brudfiguren r(x).
*The cracked concrete body with the rupture pattern r(x).
Ref.: OLSEN, DAVID HOLKMANN og M.P. NIELSEN: Ny teori til bestem-
melse af revneafstande og revnevidder i betonkonstruktioner.
(s. 28).

OLSEN, DAVID HOLKMANN og M.P. NIELSEN: Ny teori til bestemmelse
    af revneafstande og revnevidder i betonkonstruktioner.
    (*New Theory to Determine Crack Spacing and Crack Width in
    Concrete. In Danish). Afdelingen for Bærende Konstruktio-
    ner. Serie R, nr. 254, 1990. 145 s. Gratis.

Med udgangspunkt i de revneforhold der optræder i armeret beton
udvikles der en generel teori til bestemmelse af revneudviklingen
både i det tidlige og i det fuldt udviklede revnestadium.

Med det tidlige revnestadium menes det stadium, hvor armeret
beton bliver udsat for små tøjninger, f.eks. som følge af svind,
krybning eller temperaturpåvirkninger (S.K.T.-påvirkninger).

De teoretiske overvejelser resulterer i et sæt formler til be-
regning af middelrevneafstanden og middelrevnevidden som funktion
af enten spændingerne eller tøjningerne. Formlerne er gyldige for
betonkonstruktioner udsat for enakset træk og bøjning. Endvidere
er der foretaget en statistisk undersøgelse af revnefordelingen
med henblik på bestemmelse af den maksimale revnevidde.

Resultaterne af teoriens beregninger på et stort antal forsøgs-
bjælker fra litteraturen viser en god overensstemmelse med de ak-
tuelle forsøgsværdier.


*A theory of cracking of reinforced concrete is developed to de-
scribe the crack development from the very early stage to the
fully developed stage.

Cracking of reinforced concrete in the early stage is usually
caused by shrinkage, creep or temperature loading.

A set of formulas to calculate the mean crack spacing and the
mean crack width are presented as a function of either the stress
or the strain. The formulas are valid for reinforced concrete
beams subjected to uniaxial tension and bending. Furthermore, a
statistical investigation is carried out concerning crack distri-
bution in order to determine the maximum crack width.

The theoretical predictions of the mean crack width are com-
pared with a great number of experimental results from the lit-
erature, and good agreement is obtained.

OLSEN, DAVID HOLKMANN, CHEN GANWEI and M.P. NIELSEN: *Plastic
    shear solutions of prestressed hollow core concrete slabs.
    (Forskydningsbæreevnen af forspændte huldækelementer). Af-
    delingen for Bærende Konstruktioner. Serie R, nr. 257,
    1990. 17 s. Gratis.

*In this report solutions for the shear capacity of prestressed
hollow core slabs of concrete is presented.
    The solutions are based on the theory of plasticity.

I denne afhandling beskrives løsninger for forskydningsbæreevnen
af forspændte huldækelementer.
    Løsningerne er baseret på plasticitetsteorien.


RESUMEOVERSIGT 1989: "Summaries of Papers 1989". Afdelingen for
    Bærende Konstruktioner. Serie R, nr. 256, 1990. 60 s. Gra-
    tis.

Resumeer af 26 videnskabelige publikationer m.v., af 2 rapporter
over rekvirerede undersøgelser og af 13 eksamensarbejder.

*Summaries in Danish and English of 26 scientific papers etc., of
2 reports on contract work, and of 13 final year projects.


RIBERHOLT, H. og JOHANNES MORSING JOHANNESEN: Skarpe rammehjørner
    af limtræ. Arbejdsforslag fra Nordisk Gruppe. (*Sharp frame
    corners in glulam structures. Working proposals from a Nor-
    dic Group. In Danish). Afdelingen for Bærende Konstruktio-
    ner. Serie I, nr. 98, 1990. 48 s.

Dette notat indeholder de forslag, som der medio 1990 arbejdes
med i et nordisk samarbejde mellem Norge, Sverige og Danmark.
Projektet er støttet af Nordisk Industrifond og de tre landes
limtræfabrikantforeninger.
    Det er projektets mål at nå frem til løsninger på rammehjørner,

der har samme styrke som det limtræ, der forbindes i hjørnerne. Endvidere tilstræbes, at visse af hjørnerne kan udføres på byggepladsen.

*This booklet describes the proposals considered by a cooperation group from Norway, Sweden and Denmark. The project is supported by a grant from Nordisk Industrifond and the associations of glulam manufacturers in the three countries.

The purpose of the project is to develop sharp frame corners which have the same strength as the glulam connected. Further, it is the intention that some of the frame corners can be assembled on site.

SHAH, S.P., se MOBASHER, B., H. STANG og S.P. SHAH

SHAH, S.P., se STANG, H., Z. LI og S.P. SHAH

SHAH, S.P., se STANG, H., B. MOBASHER og S.P. SHAH

SHAH, S.P., se STANG, H. og S.P. SHAH

STANG, H.: *Microcrack Characterization In FRC-materials using Digital Image Analysis. (Karakterisation af Mikrorevner i Fiberarmerede Cementbaserede Materialer vha. Digital Billedanalyse). In: Proceedings of the 9th International Conference on Experimental Mechanics, 20-24 August, 1990, Copenhagen, Denmark. Department of Structural Engineering, Technical University of Denmark, 1990, pp. 1482-1493.

*A quantitative procedure for experimental characterization of microcracking patterns in fibre reinforced materials is described. The description covers an experimental procedure consisting of specimen preparation, testing, vacuum impregnation with fluorescent epoxy, thin sectioning, microscopy, and digital image processing and analysis with special emphasis on the digital im-

age processing and analysis part.

An automatic algorithm is described which makes it possible to separate the microcracks from other features – such as pores – which show up in the image acquired from the microscope. Also an image analysis procedure is described which converts the processed digital image to information describing the microcrack density, the microcrack orientation, and the total crack surface. The description of the algorithms is followed by an analysis of the possible errors introduced by the system and the algorithms. Finally, results are reported showing the microcrack development as function of the applied strain in a specific FRC- material.

En kvantitativ procedure til eksperimentel karakterisation af mikrorevner i fiberarmerede materialer beskrives. Beskrivelsen dækker en eksperimentel procedure, som består af fremstilling af prøvelegemer, prøvning, vakuum-imprægnering med fluorescerende epoxy, fremstilling af tyndslib, mikroskopering og digital billedbehandling. Der er lagt speciel vægt på beskrivelsen af den digitale billedbehandling.

En automatisk algoritme beskrives, som gør det muligt at separere mikrorevner fra andre fænomener – f.eks. porer – som dukker op i de digitale billeder. Ligeledes beskrives en billedbehandlingsprocedure, som konverterer det færdigbehandlede digitale billede til information om mikrorevnedensiteten, mikrorevneorienteringen og den totale revneoverflade. Endvidere diskuteres fejlkilderne i de beskrevne analysemetoder.

Til slut rapporteres resultater, som viser mikrorevneudviklingen som funktion af påført tøjning i et specifikt fiberarmeret cementbaseret kompositmateriale.

STANG, H., Z. LI og S.P. SHAH: *Pullout Problem: Stress versus
     Fracture  Mechanical  Approach.  (Fiberudtræks-Problemet:
     Brudmekanisk  kontra  Spændingsmekanisk  Analyse).  J.  Eng.
     Mech., Vol. 116, No. 10, pp. 2136-2150, 1990. (Reprints
     available).

*The pullout of a single fiber from a brittle matrix is widely
recognized as one of the basic tests to be performed to provide
information about the expected behavior of a given fiber-rein-
forced brittle matrix composite material. Two analytical ap-
proaches to the interfacial debonding process connected to the
fiber pullout problem can be made:
(1) The stress approach where the criterion for growth of the de-
bonded fiber/matrix interface is expressed in terms of inter-
facial stress, and
(2) The fracture mechanical approach where the criterion for in-
terfacial debonding is expressed in terms of energy equilibrium.
The paper investigates the two approaches and compares the debon-
ding-load versus crack-length relationships predicted by the two
approaches, and differences in the parametric dependency are dis-
cussed. The results predicted by the fracture mechanical approach
are compared with available experimental results.

Udtræk af en enkelt fiber indstøbt i en sprød matrix betragtes
almindeligvis som et grundlæggende forsøg, der udføres med hen-
blik på bestemmelse af et givet fiberarmeret sprødmatrix-kompo-
sitmateriales mekaniske opførsel. To analytiske fremgangsmåder
kan anvendes til analyse af den fiber/matrix adskillelsesproces,
som er forbundet med fiberudtræk: (1) Den spændingsmekaniske
fremgangsmåde, som udtrykker et kriterium for vækst af fiber/ma-
trixadskillelsen ved skillefladespændinger, og (2) Den revnemeka-
niske fremgangsmåde, som udtrykker et kriterium for vækst af fi-
ber/matrixskillefladen ved en energiligevægt. Artiklen undersøger
de to fremgangsmåder og sammenligner de udtrækskraft/skilleflade-
revnelængde-relationer, som de to fremgangsmåder forudsiger. End-
videre undersøges forskelle i de parametriske sammenhænge. Resul-
taterne forudsagt af den revnemekaniske fremgangsmåde sammenlig-

nes med tilgængelige eksperimentelle resultater.


STANG, H., B. MOBASHER and S.P. SHAH: *Quantitative Damage Cha-
    racterization in Polypropylene Fiber Reinforced Concrete.
    (Kvantitativ Skadeskarakterisering i Polypropylen-Fiberar-
    meret Beton). Cement and Concrete Research, Vol. 20, No. 4,
    pp. 540-558, 1990.


*An automatic algorithm for microcrack characterization in ce-
mentbased materials is presented. The algorithm is currently im-
plemented on a digital image analysis system at the Department of
Civil Engineering at Northwestern University. The algorithm and
test procedure are described and various error sources are de-
scribed and quantified. The algorithm is applied to crack images
obtained from a polypropylene-FRC material, and the relationship
between specific crack surface and strain as well as the rela-
tionship between an orientation measure and strain are reported
and discussed. The obtained damage evolution relationships are
compared to the observed stress/strain behavior of the pp-FRC ma-
terial.


En automatisk algoritme til kvantitativ karakterisering af mikro-
revner i cementbaserede materialer præsenteres. Algoritmen er for
tiden implementeret på et digitalt billedanalysesystem på Depart-
ment of Civil Engineering på Northwestern University, Evanston,
Illinois, USA. Algoritmen og testproceduren beskrives og forskel-
lige fejlkilder identificeres og kvantificeres. Algoritmen anven-
des på revnebilleder fra et polypropylen-fiberarmeret cementbase-
ret materiale, og sammenhængen mellem specifik revneoverflade og
tøjning såvel som sammenhængen mellem et orienteringsmål og tøj-
ningen rapporteres og diskuteres. Den målte skadesudvikling sam-
menlignes med den observerede spændings/tøjningsrelation for det
pp-fiberarmerede materiale.

STANG, H. and S.P. SHAH: *Characterization of Interfacial Bond in FRC-Materials. (Karakterisation af Binding i Skilleflader i Fiberarmerede Cementbaserede Materialer). In: Toughening Mechanisms in Quasi-Brittle Materials. NATO-ARW Proceedings, Northwestern University, July 16-20, 1990. (Ed. S.P. Shah) Northwestern University 1990, pp. 529-548. (Reprints available).

*A proper characterization of the fiber/matrix bond in fiber reinforced cementitious - FRC - composites is of great importance not only in the evaluation of the quality of a given fiber/matrix system. Different kinds of fiber/matrix debonding mechanisms are included in many models for the macroscopic mechanical behavior of FRC-materials, and the applicability of such models naturally depends on the availability of experimentally determined fiber/matrix bond parameters.

The present paper consists of a unified treatment of the fiber/matrix bond models proposed in the literature along with an evaluation of these models from an experimental and theoretical point of view. When dealing with perfectly bonded interfaces, basically two approaches are identified: the stress criterion and the fracture mechanical criterion approach. The results of these two approaches are examined and discussed. Finally, some new research directions are proposed.

Karakterisation af bindingen mellem fiber og matrix i fiberarmerede cementbaserede kompositmaterialer er af stor betydning ikke bare mht. evaluering af kvaliteten af et givet fiber/matrix system. Forskellige mekanismer for bindingen mellem fiber og matrix er inkluderet i mange modeller for den makroskopiske mekaniske opførsel af fiberarmerede cementbaserede materialer, og anvendeligheden af sådanne modeller afhænger naturligvis af, hvorvidt de indgående parametre kan bestemmes uafhængigt af modellen.

Nærværende artikel består af en ensartet beskrivelse og evaluering af en stor del af de modeller for fiber/matrix-binding, som kan findes beskrevet i litteraturen. Modeller for perfekt binding mellem fiber og matrix inddeles i to hovedgrupper: den gruppe,

som anvender et spændingsbaseret styrkekriterium, og den gruppe,
som anvender et revnemekanisk baseret styrkekriterium. Disse to
hovedgrupper undersøges og diskuteres. Til slut foreslås nye
forskningsemner inden for området binding mellem fiber og matrix
i cementbaserede materialer.

STANG, H., M. TONNESEN og E. BYSKOV: *CDM Based Constitutive
    Equations for High Strength and Fiber Reinforced Concrete.
    (Konstitutive Ligninger for Højstyrkebeton og Fiberarmeret
    Beton Baseret på Skadesmekanik). In: Micromechanics of
    Failure of Quasi-Brittle Materials. Eds. S.P. Shah, S.E.
    Swartz, and M.L. Wang. Elsevier Applied Science, 1990, pp.
    589-599.

*So called Continuum Damage Mechanics models have - during the
last decade or two - become very popular in the field of consti-
tutive modelling of quasi-brittle inhomogeneous materials such as
rock and concrete.

The present paper discusses - apart from the basic characteris-
tics of the CDM model used here - the ability of the model to
predict changes in constitutive behavior which is related to
changes in the microstructure. As case studies fiber reinforced
concrete and high strength concrete are considered. The micro-
structural characteristics of these concretes are discussed as
well as the constitutive modelling in relation to the charac-
teristics.

Theoretical predictions of material behavior in compression is
compared to experimental results.

Såkaldt skadesmekanik er gennem de sidste et til to tiår blevet
et særdeles populært værktøj til opbygning af konstitutive model-
ler for semi-sprøde inhomogene materialer såsom sten og beton.

Nærværende artikel diskuterer - ud over de fundamentale egen-
skaber ved den benyttede skadesmekanikmodel - modellens egnethed
til forudsigelse af ændringer i konstitutive betingelser, som er
relateret til ændringer i mikrostrukturen. Fiberarmeret beton og

højstyrkebeton undersøges som 'case studies'. De mikrostrukturel-
le karakteristika i disse materialer diskuteres såvel som den
konstitutive modellering set i relation til disse karakteristika.

Afslutningsvis sammenlignes teoretiske forudsigelser af materi-
aleopførsel i tryk med eksperimentelle resultater.


STANG, H., se også KRENCHEL H. og H. STANG

STANG, H., se også MOBASHER, B., H. STANG og S.P. SHAH


THOMSEN, BENTE DAHL: Undersøgelse af "Shear lag" i det elasto-
        plastiske stadium. (*Investigation of shear lag in the ela-
        sto-plastic range. In Danish). Afdelingen for Bærende Kon-
        struktioner, Serie R, nr. 250. 161 s. + appendiks 91 s.
        Gratis. /Lic./.


Den elasto-plastiske finite element (FEM)-beregning af spændings-
tilstanden i åbne kassedragere udnytter residual lastmetoden til
løsning af den inkremental teoretiske beskrivelse af materialeop-
førslen under flydeprocessen. Den matematiske plasticitetsteori
er her opbygget over Prandtl-Reuss konstitutive betingelser og
Huber-Mises associerede flydefunktion. Under flydningen relateres
den effektive spænding til den effektive tøjning ved hjælp af en
modificeret Ramberg-Osgood relation og målte materialeparametre.

FEM-programmet er valideret ved sammenligning med observationer
fra den eksperimentelle undersøgelse af seks ståldragere, med tre
forskellige bredder, belastet med punktformige kræfter på kroppe-
ne. Omsætningen af tøjninger målt med strain gages rosetter til
repræsentative spændinger er baseret på deformationsteorien. Te-
sten tyder på, at visse fænomener ikke er beskrevet korrekt.

For de i denne undersøgelse behandlede dragere reduceres shear
lag effekten i de brede flangeplader, indtil plastificeringen har
nået flangemidten. Det er endvidere sandsynliggjort, at denne
proces vil ophøre, i det øjeblik flange- eller kroppladens for-
skydningskapacitet er udtømt.
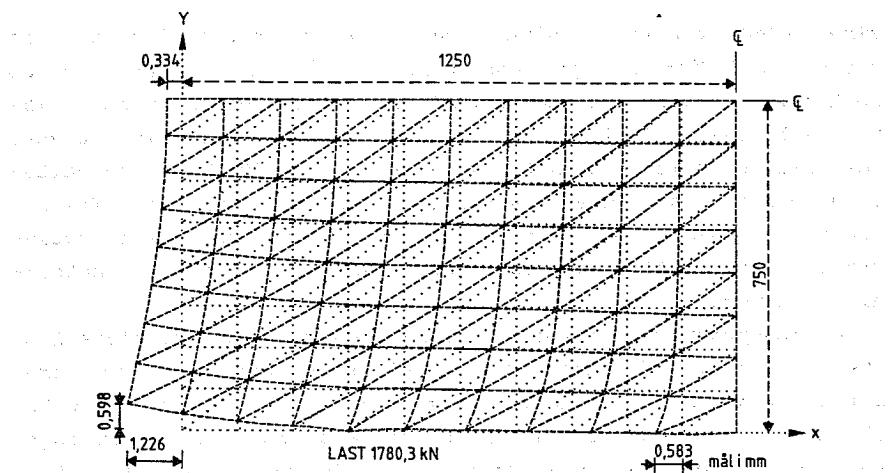
Deformationsfiguren for drager SL P2's flangeplade.
*The flange deformation of the girder SL P2.
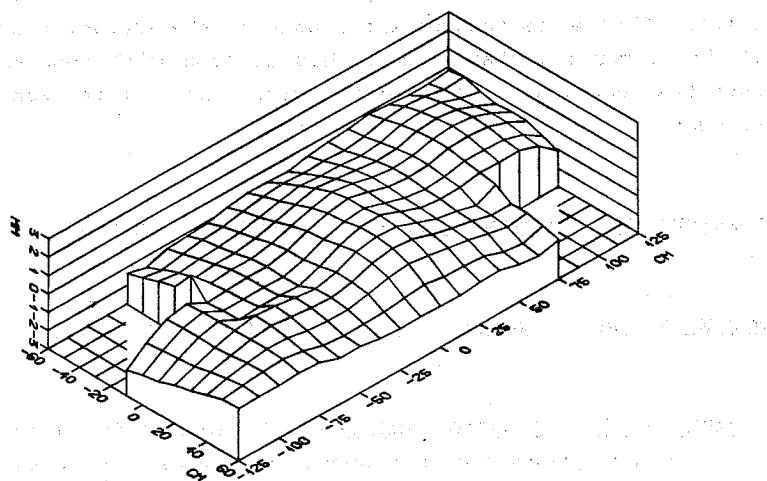


Initialudbøjning for drager SL P4.
*Initial displacement of girder SL P4.
Ref.: THOMSEN, BENTE DAHL: Undersøgelse af "Shear lag" i det ela-
sto-plastiske stadium. (s. 36).

*The elasto-plastic finite element (FEM)-computation of the stress condition in open box girders uses the residual forces method for solving the incremental theoretical description of material behaviour during the flow process. The mathematical theory for plasticity is in this thesis based on Prandtl-Reuss constitutive equations and Huber-Mises associated yield function. The effective stress during plastic flow is related to the effective strain by a modified Ramberg-Osgood relation and measured material parameters.

The FEM-program is checked by comparison with observations from the experimental investigation of six steel girders, with three different widths, loaded with concentrated forces at the webs. The transformations of the strain signals from the strain gages rosettes to representative stresses are based on the deformation theory. The test indicates that the description of some phenomena is not correct.

For the girders treated in this investigation, the shear lag effect in the wide flange plate is gradually reduced as the plastic flow moves towards the middle of the flange. Furthermore, it is rendered probable that this process will come to an end when the shearing capacity of the wide flange or the web plate is reached.


TONNESEN, M., se STANG, H., M. TONNESEN og E. BYSKOV


WICHE, S., se ASKEGAARD, V., L.O. NIELSEN og S. WICHE


YAMADA, K. and HENNING AGERSKOV: *Fatigue life prediction of welded joints using fracture mechanics. (Brudmekanisk bestemmelse af udmattelseslevetiden af svejste samlinger). Afdelingen for Bærende Konstruktioner. Serie R, nr. 255, 1990. 54 s. Gratis.

*Fracture mechanics approach has proved to be one of the most
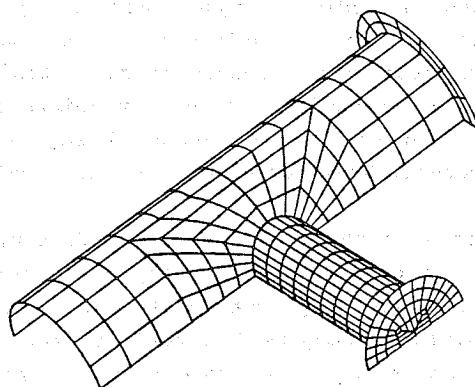
Elementinddeling til beregning af rørknude prøvelegeme.
*Finite element mesh for analysis of tubular joint test specimen.
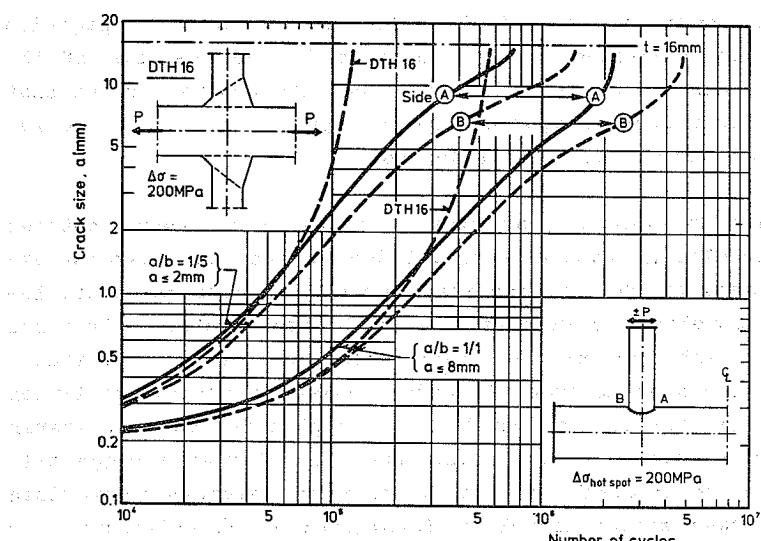


Vækst i udmattelsesrevner i rørsamling og i trækforbindelse.
*Fatigue crack growth behavior of tubular joint and tensile specimen.

Ref.: YAMADA, K. and H. AGERSKOV: Fatigue life prediction of welded joints using fracture mechanics. (s. 38).

promising techniques to predict fatigue crack propagation life of welded steel structures. This technique is in the present investigation used to analyse welded specimens subjected to constant and variable tension/compression and tubular joints subjected to constant amplitude in-plane bending loads, being tested at the Department of Structural Engineering of the Technical University of Denmark.

The report consists of three parts. First, fracture mechanics approach to fatigue crack propagation analysis is summarized and a description of the computer program VARFAT is given. This program makes it possible to compute the fatigue crack propagation life for variable amplitude stress cycles. Next, the program is used to analyse plate elements with welded attachments subjected to constant and variable amplitude stress cycles. The effect of the stress spectrum on the fatigue life in the long life region is also discussed. Finally, the program is applied to the tubular joints to determine analytically the fatigue crack propagation life. Although various assumptions made in the analysis of the tubular joints are still to be clarified, the analysis shows that the fracture mechanics approach can be applied to verify the fatigue behaviour of the tubular joints.

Brudmekanik har vist sig at være en af de mest lovende metoder til bestemmelse af udmattelseslevetiden af svejste stålkonstruktioner. Denne metode anvendes i den aktuelle undersøgelse til levetidsbestemmelse for svejste konstruktionselementer, udsat for spændingsvariationer med konstant eller varierende amplitude. Endvidere anvendes metoden til undersøgelse af rørknudesamlinger udsat for lastvariationer med konstant amplitude, og hvor lasten resulterer i bøjning i konstruktionens plan. Der er i begge tilfælde tale om konstruktionssamlinger, hvor udmattelseslevetiden også bestemmes eksperimentelt i forsøgsserier på Afdelingen for Bærende Konstruktioner, DTH.

Rapporten består af tre dele. Først er der givet en oversigt over brudmekanikkens anvendelse til levetidsbestemmelse, samt en beskrivelse af EDB-programmet VARFAT. Med dette program kan udmattelseslevetiden bestemmes for konstruktioner udsat for last

med varierende amplitude. Dernæst anvendes programmet til leve-
tidsbestemmelse for pladeelementer med påsvejste tværafstivninger
ved såvel konstant som varierende lastamplitude. Specielt er un-
dersøgt indflydelsen fra spændingsspektrets form på udmattelses-
levetiden ved et stort antal påvirkninger. Endelig anvendes pro-
grammet til en analytisk bestemmelse af udmattelseslevetiden for
svejste rørknudesamlinger. Selvom der fortsat er forudsætninger
for disse beregninger, som ønskes undersøgt nøjere i det fortsat-
te arbejde, viser de gennemførte undersøgelser, at brudmekanikken
også er en anvendelig metode til bestemmelse af udmattelses-
levetiden for rørknudesamlinger.


YAMADA, K and H. AGERSKOV,: *Fatigue Analysis of Plate Elements
        with Groove Welded Attachments using Fracture Mechanics.
        (Brudmekanisk bestemmelse af udmattelseslevetiden af plader
        med påsvejste tværafstivninger). International Institute of
        Welding, Annual Assembly, Montreal, July, 1990, IIW Doc.
        XIII-1365-90, 18 pp. (Reprints available).


*The fatigue life of plate elements with groove welded attach-
ments is studied in the present investigation. This project is a
part of a larger research program, in which the fatigue life of
offshore structures is investigated under various types of spec-
trum loading and under various corrosion conditions.

   In the present investigation, fracture mechanics approach is
used to determine the fatigue crack propagation life under both
constant and variable amplitude stress variations, and the analy-
tical results are compared with test results. The fracture mecha-
nics analysis makes possible an evaluation of the fatigue crack
propagation with different weld toe geometries, possible thick-
ness effects, and the possible differences in fatigue life be-
tween the test specimens of the present investigation and similar
specimens with fillet welded attachments.

   For the fatigue crack propagation analysis with variable ampli-
tude stress variations, the stress spectra are derived from two-
parameter Weibull distributions. In the analysis, special atten-

tion is paid to the effect from a large number of cycles with low stress range levels on the fatigue crack propagation life.


AARKROG, PETER: *A Computer Program for Servo Controlled Fatigue
     Testing. Documentation and User Guide. (Et Computerprogram
     til Servostyret Udmattelsesprøvning. Dokumentation og Bru-
     gervejledning). Afdelingen for Bærende Konstruktioner. Se-
     rie R, nr. 253, 1990. 68 s. Gratis.

*A principle of controlling servo systems for fatigue testing at frequencies around 100 load cycles pr. second is presented. The load history is generated using a Markov model which enables the use of stochastic load spectra for the testing. The principle has been implemented on a micro computer, and results of experiments carried out on a servo controlled fatigue testing equipment is presented. Documentation as well as a user guide to the program is given.

Der præsenteres en metode til at kontrollere servostyrede udmat-telsesopstillinger, der kan benyttes til prøvning ved ca. 100 på-virkninger pr. sekund. Lastforløbet genereres ved brug af en Mar-kov model, hvilket muliggør brug af stokastiske lastspektre. Me-toden er implementeret på en microcomputer, og resultaterne af en afprøvning på en servostyret hydraulisk presse præsenteres. Rapporten indeholder desuden dokumentation og vejledning til det opbyggede program.


AARKROG, PETER: Brugervejledning til Tantalus. Et Computerprogram
     til Servostyret Udmattelsesprøvning. (*User Guide to Tanta-
     lus. A Computer Program for Servo Controlled Fatigue Tes-
     ting. In Danish). Afdelingen for Bærende Konstruktioner.
     Serie I, nr. 95, 1990. 24 s.

Rapporten er en vejledning i brug af programmet Tantalus, der er udviklet til udmattelsesprøvning i servostyrede udmattelsesop-

stillinger, hvor den påførte last genereres ud fra en på forhånd
beregnet Markov matrix. Rapporten indeholder en gennemgang af
inddata til programmet, information under forsøgsafviklingen, en
oversigt over fejlmeddelelser med tilhørende forklaring samt en
omtale af resultatudskriften.

*The report contains a guide to the use of the program Tantalus
developed for fatigue testing in servo controlled test equipment.
The applied load is generated using a Markov model which enables
the use of stochastic load spectra. Input, information while run-
ning the test, an overview of error messages from the program,
and an example of the output of results is given.

## REKVIREREDE UNDERSØGELSER

### *Reports on contract work

Rapporten over en rekvireret undersøgelse er principielt rekvi-
rentens ejendom, men dels kan der altid gives rent orienterende
oplysninger om, hvad Afdelingen kan udføre af målinger på det på-
gældende felt ved henvendelse til den person, der er angivet un-
der sagen, og dels er det muligt i visse sager at udlevere en fo-
tokopi af rapporterne, dersom rekvirenten har givet sin tilladel-
se hertil.

*A report on contract work is, in principle, the property of the
client, but information on the types of measurement undertaken by
the Department in the field in question can always be obtained by
application to the person named under the project, and for cer-
tain projects, a photocopy of the reports can be supplied pro-
vided the client has given his consent to this.

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I 1990 har Afdelingen gennemført forholdsvis få rekvirerede un-
dersøgelser, herunder bl.a. afprøvning af en møllevingesektion,
som beskrevet nedenfor. Se også Resuméoversigt 1987.

Dette forhold er i det væsentlige en følge af, at Afdelingens
forsøgskapacitet i perioden i overvejende grad har været knyttet
til meget omfattende aktiviteter inden for det materialeteknolo-
giske udviklingsprogram under Teknologistyrelsen, bl.a. vedrøren-
de Cementbaserede Kompositmaterialer og Højstyrkebeton.

*During 1990 the Department only performed a rather small amount
of contract work, among which a test on a wind turbine blade is
described below (see also Summaries of Papers 1987).

This temporary reduction in contract work is mainly due to the
fact that the experimental capacity of the Department during this
period was utilized on extensive investigations under the Danish
Materials Technology Development Program, such as Cementbased
Composite Materials and High Strength Concrete.

Udmattelsesforsøg_med_Befæstigelse_for_Limtræsvinge. (*Fatigue
test on attachment for wind turbine blade made of glulam.
In Danish). ABK, serie S nr. 9022.

Der er for DEFU udført forsøg med en vingebefæstigelse for en
vindmøllevinge af en hul limtrætssektion. Specielt samlingen be-
stående af 28 indlimede bolte mellem vingens limtræsdel og vin-
gens ståldel ønskedes undersøgt. Der blev ikke efter $100 \times 10^6$
pulsationer ved ± 275 kNm observeret udmattelsesbrud i samlingen.
Rapporten vil foreligge i løbet af 1991.
  Rekvirent: DEFU.
  Yderligere oplysninger: Finn Johnsen.

*A fatigue test has been carried out for DEFU on an attachment
for a wind turbine blade made of a hollow section of glulam. Par-
ticular attention was paid to the connection between the glulam
blade and the steel flange which connects the blade to the rotor
shaft. The connection consisted of 28 bolts glued into the glu-
lam.

  It was found after $100 \times 10^6$ pulsations at ± 275 kNm that fa-
tigue failure did not occur in the connection.
  Client: DEFU (Research Association of the Danish Electricity
Supply Undertakings).
  Further information: Finn Johnsen.

## 3. EKSAMENSPROJEKTER

### *Final year projects

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Yderligere oplysninger om afhandlingernes indhold fås ved hen-
vendelse til den under resumeet angivne lærer.

Anmodning om kopiering kan ske telefonisk på tlf. 42 88 35 11.

*As there is normally only one copy of each of these theses,
anyone wishing to study them in detail must do so at the Depart-
ment's library according to a previous arrangement. Photocopies
of entire theses or parts thereof can, however, be supplied at a
price of D.kr. 1.00 per page. Orders for copies must be accompa-
nied by a cheque for the amount in question.

Further information on the content of the theses can be ob-
tained by application to the project leader indicated under the
summary.

ASGEIRSSON, VILHJALMAR ARNI: Projektering af en sportshal. (*De-
    sign of a sports hall. In Danish). Eksamensprojekt, Afde-
    lingen for Bærende Konstruktioner, 1990, 90 s. + 60 s. app.
    Fotokopi, kr. 150,-.

Der er udført en projektering af en større sportshal, hvor de bæ-
rende konstruktioner i væg og tag er tænkt udført enten i stål
eller træ.
  Lærer: Hilmer Riberholt.

*A large sports hall has been designed. The structures in the
walls and the roof have been assumed to be of steel or timber
based.
  Project leader: Hilmer Riberholt.

BIRKELUND, PER og SVEN BØG HANSEN: Sammenligning af flerfags
    skråstagsbroer med forskellige kabelsystemer. (*Analysis of
    Multispan Cable-Stayed Bridges. In Danish). Eksamenspro-
    jekt, Afdelingen for Bærende Konstruktioner, 1990, 165 s. +
    bilag. Fotokopi, kr. 165,-.

I forbindelse med nye store broprojekter, f.eks. en fast forbin-
delse fra Danmark til Tyskland over Fehmern Bælt, er det af stor
interesse at undersøge flerfags skråstagsbroer. I projektet un-
dersøges forskellige alternative udformninger af kabelsystemet,
hvor der enten anvendes overlappende kabler eller ekstra kabler
mellem pylonerne. Undersøgelserne omfatter både skråstagsbroer
over 2 og 5 fag, og der undersøges forskellige former for mid-
terpyloner. Analyserne er foretaget med elementprogrammet Pafec,
og der er udviklet rutiner til behandling af egenvægtsbelastnin-
gen og dimensioneringen af de enkelte elementer. I forbindelse
med behandling af broer over mange fag er der undersøgt forskel-
lige tilnærmelsesmetoder til reduktion af beregningsomfanget. Al-
ternativerne er sammenlignet på basis af materialeforbrug og
stivhedsforhold.
  Lærere: Lars Damkilde og N.J. Gimsing.

*In connection with new, large bridges, e.g. a bridge between Denmark and Germany crossing the Fehmern Belt, it is of great interest to investigate multispan cable-stayed bridges. Different cable systems are examined based on either overlapping cables or extra cables connecting the pylons. The investigation includes both cable-stayed bridges over 2 or 5 spans and different designs of the pylons. The finite-element program Pafec has been used in the calculations, and different routines are developed for the gravity load and the code-checks for the elements. For bridges over many spans an approximate method has been examined, and thereby the amount of calculations has been reduced significantly. The different designs are compared based on the material costs and the stiffness of the bridge.

Project leaders: Lars Damkilde and N.J. Gimsing.


HANSEN, SVEN BØG, se BIRKELUND, PER og SVEN BØG HANSEN

JACOBSEN, BENT B., se NIELSEN, KARSTEN og BENT B. JACOBSEN

JENSEN, JØRN JACOB, se JOHANNESEN, JOHANNES MORSVIG og JØRN JACOB JENSEN


JOHANNESEN, JOHANNES MORSVIG og JØRN JACOB JENSEN: Ikke-lineære pladeberegninger (*Nonlinear plate bending analysis. In Danish). Eksamensprojekt, Afdelingen for Bærende Konstruktioner, 1990, 186 s. + 46 s. bilag. Fotokopi, kr. 232,-.

Der er opstillet elementmetodeformulering for tværbelastede plader under hensyntagen til geometriske og materialemæssige ikke-lineariteter. Formuleringen er implementeret i et elementmetodeprogram og aftestet.

Lærer: Leif Otto Nielsen.


*A finite element method formulation for lateral loaded plates is developed considering geometric and material non-linearities. The

formulation is implemented in a finite element computer program
and tested.

Project leader: Leif Otto Nielsen.


NIELSEN, KARSTEN og BENT B. JACOBSEN: Analyse af komposit skrå-
    stagsbro. (*Analysis of composite cable-stayed bridge. In
    Danish). Eksamensprojekt, Afdelingen for Bærende Konstruk-
    tioner, 1990, 140 s. + 55 s. bilag + edb-udskrifter. Foto-
    kopi, kr. 195,-.

Fri frembygning af komposit skråstagsbro foretages mest hensigts-
mæssigt ved to stag-opspændinger. Der udvikles en metode til be-
stemmelse af stag-opspændinger ved montagen ud fra en given egen-
vægtstilstand.

Svind og krybning i betonpladen af komposit-afstivningsdrageren
undersøges med hensyntagen til montagen. Der søges en lettere me-
tode til beregning af svind og krybningsbidrag til egenvægtstil-
standen. Ved at påføre den fulde egenvægt på det endelige brosy-
stem til tiden T/2, hvor T er tiden for montagen, opnås en rime-
lig tilnærmelse af svind- og krybningspåvirkningerne.

Endelig undersøges fordelingen af stagkræfterne i betonpladen
ved skiveberegning.

Lærer: Niels J. Gimsing.


*Erection of a cable-stayed bridge with a composite girder sec-
tion is most favorably accomplished by tensioning the stays in
two stages.

A method is developed to determine the initial cable tensions
so as to arrive at a desired dead load condition.

The influence of shrinkage and creep of the concrete slab is
studied and it is found that a good approximation can be reached
by assuming the entire dead load applied to the final structure
at time T/2, where T is the total erection period.

Project leader: Niels J. Gimsing.

TINNING, HENRIK: EDB-beregning af trækonstruktioner. (*Computer
        analysis of timber structures. In Danish). Eksamensprojekt,
        Afdelingen for Bærende Konstruktioner, 1990, 36 s. + 61 s.
        app. Fotokopi, kr. 97,-.


Der er udviklet et FEM-program til analyse af plane trækonstruk-
tioner vha. bjælkeelementer samt nogle særlige forbindelsesele-
menter. Disse tager hensyn til de enkelte forbindelsesmidlers
placering i forbindelsen samt deres ikke-lineære arbejdskurve.
Deres arbejdskurve kan indgives som en kombination af et n'te
grads polynomium og en eksponentialfunktion.

   Systemligningerne løses vha. Residuallastmetoden, der har vist
sig effektiv for konstruktioner af moderat størrelse, når analy-
sen foretages på en PC.

   Lærer: Hilmer Riberholt.


*A FEM-program has been developed for the analysis of plane tim-
ber structures by means of beam elements and some special connec-
tion elements. These take into account the position of each con-
nector in the connection and their non-linear load-slip curve.
The shape of these curves is determined by the input. They can be
a combination of a polynomium of n'th degree and an exponential
function.

   The system equations are solved by means of a Residual load
method, which has proved to be effective for structures of mod-
erate size when analyzed on a PC.

   Project leader: Hilmer Riberholt.

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R 242.   KRENK, STEEN og THORUP, ERIK: Stochastic and Concrete Amplitude Fatigue Test of Plate Specimens with a Central Hole. 1989.
R 243.   AARKROG, P., THORUP, E., KRENK, S., AGERSKOV, H. and BJØRN-BAK–HANSEN, J.: Apparatur til Udmattelsesforsøg. 1989.
R 244.   DITLEVSEN, OVE and KRENK, STEEN: Research Workshop on Stochastic Mechanics, September 13–14, 1988.
R 245.   ROBERTS, J.B.: Averaging Methods in Random Vibration. 1989.
R 246.   Resumeoversigt 1988 – Summaries of Papers 1988. 1989.
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