EUROMECH Newsletter 27
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President's Address

As detailed elsewhere in this newsletter, the European Mechanics Society has recently established two types of awards to recognize highly deserving members of our community. The *EUROMECH Fluid and Solid Mechanics Prizes* are conferred to colleagues who have made "outstanding and fundamental research accomplishments in Mechanics". The first recipients in 2003 were Professor Keith Moffatt of the University of Cambridge and Professor Franz Ziegler of Vienna University of Technology. The deadline for the submission of the next round of nominations is *15 January 2006*. The new status of *EUROMECH Fellow* is awarded to members who have "contributed significantly to the advancement of mechanics and related fields". The deadline for the submission of nomination packets is also *15 January 2006*. Now is the time to nominate fluid and solid mechanicists whom we believe should be recognized for their accomplishments. In both cases the procedure is straightforward. Please refer to pages 22 - 26 of this newsletter for nomination instructions.

It is also the appropriate time to warmly thank Mila Okrouhlik and Emil Hopfinger, who have been Secretary-General and Treasurer from 1998 to 2004. Through their distinguished and generous service, EUROMECH has truly become *the* Society of European Mechanicists. As of January 1 of this year, Bernhard Schrefler (University of Padova) and Wolfgang Schröder (RWTH-Aachen) have joined the officers' team as Secretary-General and Treasurer respectively. The Society will greatly benefit from their experience on behalf of EUROMECH.

We have significantly increased the seed contribution of EUROMECH for colloquia and we very much expect that it will lead to many interesting proposals. Please spread the word around!

Patrick Huerre

President, EUROMECH

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Wladyslaw Fiszdon

12 June 1912 – 25 October 2004

Wladyslaw Fiszdon, an Honorary Member of the EUROMECH Society, passed away in October 2004 after a long illness.

Wladek, as he was known to his many friends all over the world, was among the participants of Euromech Colloquium 2 at Liverpool in 1966. He took part in the meeting of the Euromech Interim Committee at Vienna in June 1966, becoming a member of the Euromech Committee in 1969 on which he remained for the next fourteen years. His professional and personal experience gathered in Eastern and Western European countries as well as in the United States enabled him to play an important role on the Committee both in scientific matters and in dealing with various humane and political problems, the latter arising mainly from Euromech's contacts with Eastern Europe. All members of the Committee were impressed by his ability to find solutions and by his balanced counsel given with great honesty and reliability.

Fiszdon was born in a small village, Kozin, in the poorest part of Eastern Poland. After his education in a small secondary school the local priest secured a scholarship for Wladek so that he could attend the Sorbonne in Paris to study mathematics and astronomy. The dream of studying this had to be abandoned, since in the event he was only able to obtain a stipend to study aeronautical engineering at the Ecole National Superieure de l´Aeronautique where he graduated in 1935 with the title of Engineer. Having returned to Poland he began work in an aircraft factory in Lublin. He moved the machinery from the factory at the beginning of World War II to a region close to the Romanian border, but at the collapse of Poland he crossed the border to Romania, escaped via the Balkans to France and from there to the UK with the intention to join the Polish forces in England. His education in aeronautics brought him to RAE Farnborough where he was impressed by the style of working together and the civil discipline based on integrity and personal prestige independent of any formal rank or professional degree. When the war ended, Wladek had the title of senior scientific officer, in charge of a section of RAE dealing with vibration and dynamic loads and an offer to remain in the

UK. With his wife and his son in Poland, he returned, however, to the ruins of Warsaw.

In May 1946, together with other enthusiasts, Fiszdon organised the Institute of Aeronautics and became its director. With the onset of the cold war and the strict communist rule everything changed, the dream of building a counterpart of RAE Farnborough came to an end.

He began to lecture on the mechanics of flight and aircraft aerodynamics at Warsaw Technical University in February 1947 where he received his Ph.D. degree in aeroelasticity in 1951. During the subsequent years his scientific interests shifted to the physics of fluid flows. After a year at MIT in 1957 Fiszdon took up a lectureship at the University of Warsaw. From 1969 he assumed new duties in the Department of Mathematics and Mechanics of the University and at the Institute of Fundamental Technological Research as the head of the Fluid Mechanics Department. Here he procured international recognition for the Biennial Fluid Dynamics Symposium, a conference which lasted until the end of the eighties. Fiszdon became a member of the Polish Academy of Sciences in around 1970, allowing him more freedom of movement in this travels and more possibilities to promote the new generation of scientists. He showed great skill and courage in his movements in the dangerous world of Stalinist and later Gomulka Poland so that he could always maintain his contacts to the West.

In the beginning of the eighties Fiszdon was elected to the Presidium of the Academy of Sciences and became Deputy Chancellor of Warsaw University. After the introduction of martial law in Poland in December 1981 he was repeatedly interrogated by the police and unable to pursue normal scientific work. The great stress of this period of life was relieved by an invitation from E.A. Müller at the Max-Planck-Institut für Strömungsforschung at Göttingen and by friends at other universities to spend about eight months per year outside Poland. Wladek Fiszdon and his wife Kamilla returned to Warsaw in May 1994 when he had his second stroke. Having been an extremely hard and passionate worker, both in the pursuit of science and in its organization, he understood scientific work as a personal responsibility, the main challenge, and the main duty of his life.

H.H. Fernholz R. Herczynski

Cosserat Continuum Analyses For Cellular Materials

Cihan Tekoglu[1], Patrick Onck[1]

Chian Tekoglu won the EUROMECH Young Scientist Prize, awarded at the fifth EUROMECH Solid Mechanics Conference
Thessaloniki, August 2003

1 Introduction

The focus of this work is on the mechanical properties of materials with a cellular structure. Natural materials, such as wood and cancellous bone, and engineering materials, such as honeycombs and foams are good examples of cellular solids.

Experiments performed on different kinds of cellular solids [1,2] show that the mechanical properties of these materials strongly depend on the cell size relative to the specimen size, especially in the regime where these two are of the same order of magnitude. Classical continuum theory, which does not contain a length-scale, is not able to capture these size effects. One way to approach this problem is to take the discreteness of the microstructure into account by modelling each cell wall as a beam element. This method gives good agreement with experiments, but is computationally too expensive, especially for complex microstructures. Another approach is to use a generalized continuum theory. One of the simplest generalized continuum theories is Cosserat continuum theory, where rotations are introduced as independent degrees of freedom, in addition to displacements. As a result, the interaction between two material points not only occurs via force stresses, which is the case in the classical continuum theory, but also via couple stresses. This requires new elastic constants relating the derivative of rotations (curvatures), to couple stresses. Experimental methods to obtain these additional constitutive constants do not yet exist, while the available Cosserat homogenisation/averaging approaches for irregular microstructures suffer from a dependence of the resulting effective constants on the specific choice of boundary conditions and RVE size (e.g. [4-5]).

The aim of this work is to obtain these Cosserat elastic constants by computational micromechanics. Different microstructural shapes are used to model the cellular solid, including squares, and perfect and perturbed honeycombs. Figure 1 shows the microstructures tested. We solve a simple shear boundary value problem, first by performing finite element analyses on the discrete model and then analytically by using Cosserat continuum theory.

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We fit the elastic Cosserat constants of the material by comparing the two solutions in terms of the best agreement on the macroscopic shear modulus.

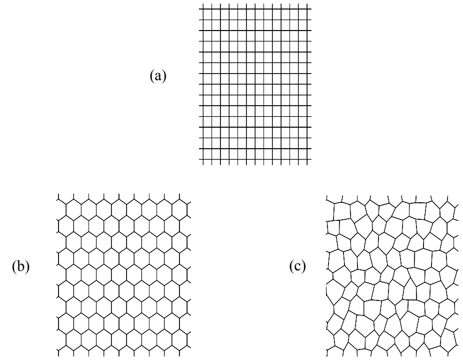

Fig. 1. (a) Square microstructure. (b) Perfect hexagonal microstructure. (c) Perturbed hexagonal microstructure.

2 Discrete Models

Figure 2 shows the boundary conditions corresponding to a shear test on a sandwich panel having the cellular solid (with a square microstructure, as an example) as a core. We model each cell wall by Timoshenko beam elements. To avoid the edge effects common to the shear problem, we assume an infinitely long material in the x_1 direction. This condition is introduced by applying periodic boundary conditions at both sides of the sample.

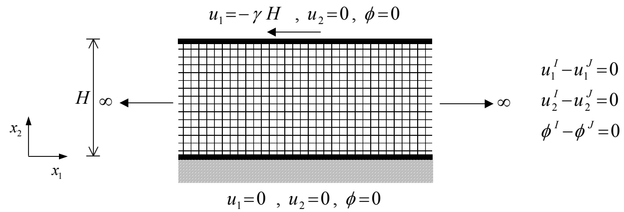

Fig. 2. The boundary value problem for simple shear of a specimen with square microstructure.

The value of the macroscopic shear modulus depends on the length and the connection angle of the cell walls bonded to the top and bottom face sheets. We analysed almost all the possible connection combinations for a single *H*/*d* ratio, by taking different cuts from the same sample. The number of cuts that has to be taken to cover the whole range of possibilities depends on how regular the microstructure is and is determined by performing convergence tests. Figure 3 shows the different cuts for the square microstructure, for *H*/*d* = 2, as an example. Figure 4 shows the macroscopic shear modulus (*G*) normalized by the classical shear modulus (G_{class}) plotted against the normalized height (H/d), for the square microstructure. The classical shear modulus is the shear modulus corresponding to an infinitely large sample with the same microstructure. The curves named as "Upper bound" and "Lower bound" are created by simply connecting the highest and the lowest data points in different regimes, respectively. We observe a large scatter in the value of the macroscopic shear modulus, especially in the small H/d regime. However, on average, there is a strong strengthening ($G/G_{class} > 1$) behaviour in this regime. This strengthening is explained by the existence of a boundary layer caused by the constrained rotations at the top and the bottom face sheets. As we increase the height of the structure, the standard deviation tends to zero and the macroscopic shear modulus (G) converges to the classical shear modulus (G_{class}).

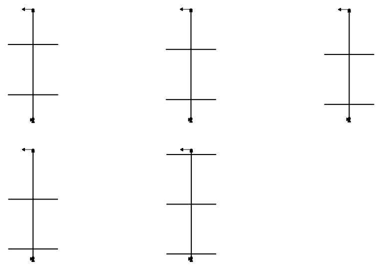

Fig. 3. Different connection configurations of the cell walls to the rigid plates.

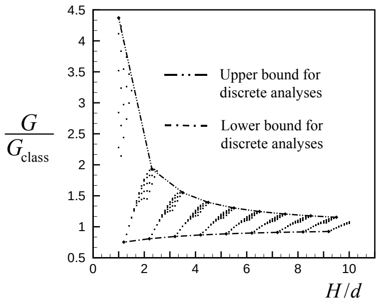

Fig. 4. G/G_{class} plotted against H/d, for the square microstructure (5 different cuts per H/d).

The behaviour of the hexagonal microstructures depends on the orientation of the hexagons. We analysed two different orientations (default and rotated). Figures 5, 6, 7, and 8 show the macroscopic shear modulus (G) normalized by the classical shear modulus (G_{class}) plotted against the normalized height (H/d), for the microstructures with perfect hexagons in the default orientation, perfect hexagons in the rotated orientation, perturbed hexagons in the default orientation and perturbed hexagons in the rotated orientation, respectively. The trend of the macroscopic shear modulus with increasing height is similar in each case. In the small H/d regime, there is a strengthening behaviour on average, with a large scatter in data, and with increasing height (H/d) the macroscopic shear modulus converges to its classical counterpart. For the perfect hexagons, however, the dependence on the loading direction is more pronounced compared to the perturbed hexagons.

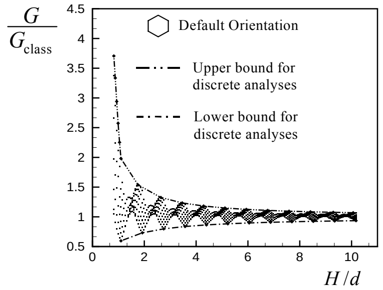

Fig. 5. G/G_{class} plotted against H/d, for the perfect hexagonal microstructure, default orientation (6 different cuts per H/d).

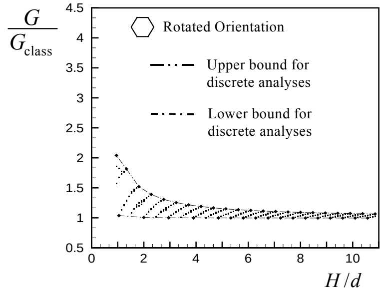

Fig. 6. G/G_{class} plotted against H/d, for the perfect hexagonal microstructure, rotated orientation. (8 different cuts per H/d).

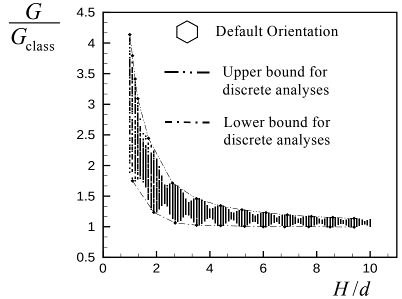

Fig. 7. G/G_{class} plotted against H/d, for the perturbed hexagonal microstructure, default orientation (100 different cuts per H/d).

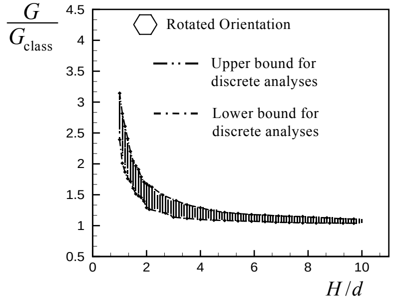

Fig. 8. G/G_{class} plotted against H/d, for the perturbed hexagonal microstructure, rotated orientation (100 different cuts per H/d).

3 Cosserat Continuum Theory

Rotations as well as displacements are introduced as independent degrees of freedom in the Cosserat theory. This incorporates new constants in the elasticity matrix. The coefficients of the elasticity matrix in terms of symmetric (s_{ij}, ε_{ij}) and antisymmetric (τ_{ij}, α_{ij}) components of the stresses and strains reduce for a square lattice to

$$s_{11} = C_{1111}\varepsilon_{11},\ s_{22} = C_{2222}\varepsilon_{22},\ s_{12} = A_{1212}\varepsilon_{12},$$
$$\tau_{12} = A_{2121}\alpha_{12},\ m_{13} = D_{1313}\kappa_{13},\ m_{23} = D_{2323}\kappa_{23}. \quad (1)$$

For the simple shear problem, the kinematic and equilibrium equations of the Cosserat theory reduce to

$$\varepsilon_{11} = 0,\ \varepsilon_{22} = 0,\ \varepsilon_{12} = \frac{1}{2}\frac{du_1}{dy},\ \alpha_{12} = -\frac{1}{2}(\frac{du_1}{dy} + 2\phi),\ \kappa_{13} = 0,\ \kappa_{23} = \frac{d\phi}{dy}, \quad (2)$$

$$\frac{d(s_{12}-\tau_{12})}{dy}=0, \qquad \frac{dm_{23}}{dy}+2\tau_{12}=0. \tag{3}$$

Inserting (2) into (3) via the constitutive equations yields

$$(m+1)\frac{d^2u_1}{dy^2}+2m\frac{d\phi}{dy}=0\,, \tag{4}$$

$$l_c^2\frac{d^2\phi}{dy^2}-2m\phi-m\frac{du_1}{dy}=0, \tag{5}$$

with

$$m=\frac{A_{2121}}{A_{1212}}, \quad l_c^2=\frac{D_{2323}}{A_{1212}}. \tag{6}$$

The parameter l_c has the dimension length and is often called the characteristic length, whereas m is a dimensionless parameter. The solution of the differential equations reads

$$\phi=C_1+C_2e^{\omega y}+C_3e^{-\omega y}, \tag{7}$$

$$u_1=C_4-2C_1y-PC_2e^{\omega y}+PC_3e^{-\omega y}, \tag{8}$$

with eigenvalue ω and coefficient P defined as

$$\omega=\frac{1}{l_c}\sqrt{\frac{2m}{m+1}}, \quad P=l_c\sqrt{\frac{2m}{m+1}}\ . \tag{9}$$

The remaining constants are determined by inserting the boundary conditions given in Figure 2, and are given by

$$C_1=\frac{\gamma H(e^{\omega H}-e^{-\omega H})}{2P(2-e^{\omega H}-e^{-\omega H})+2H(e^{\omega H}-e^{-\omega H})}\ , \tag{10}$$

$$C_2=-\frac{\gamma H(1-e^{-\omega H})}{2P(2-e^{\omega H}-e^{-\omega H})+2H(e^{\omega H}-e^{-\omega H})}, \tag{11}$$

$$C_3=\frac{\gamma H(1-e^{\omega H})}{2P(2-e^{\omega H}-e^{-\omega H})+2H(e^{\omega H}-e^{-\omega H})}, \tag{12}$$

$$C_4=-\frac{\gamma HP(2-e^{\omega H}-e^{-\omega H})}{2P(2-e^{\omega H}-e^{-\omega H})+2H(e^{\omega H}-e^{-\omega H})}. \tag{13}$$

Note that a similar analysis for an isotropic (hexagonal) material has been performed in [6]. The solution converges to the solution for classical elasticity for $m \to 0$ and to couple stress theory for $m \to \infty$. Figure 9a shows the normalized shear stiffness, G/G_{class} (G_{class} is given in eq. (1) and is equal to

$A_{1212}/2$), versus normalized height, H/d, for different values of m and fixed l_c/d. Stiffening becomes more and more pronounced as m approaches to the couple stress limit for $m \to \infty$. Figure 9b shows G/G_{class} versus H/d for m = 1 (Cosserat theory) with increasing l_c/d. The tendency is similar to the previous case although the gradient of G is much smaller. Figure 9c shows the normalized rotation ϕ/ϕ_0 ($\phi_0 = \gamma/2$) through the thickness of the specimen, for H/d = 10 using Cosserat theory (m = 1). The thickness of the boundary layer increases with increasing l_c/d ratio. A similar effect is found for l_c/d = 1 and increasing m (not shown here). Figure 9d shows G/G_{class} versus H/d for the couple stress limit. Comparing Figs. 9d and 9b, it can be concluded that the strengthening effect with increasing l_c/d for small H/d is much more pronounced for couple stress theory than Cosserat theory.

4 Discussion

We fit the discrete calculations to the Cosserat continuum solutions to obtain the optimal coefficients. The discrete analyses show a large scatter in the value of the macroscopic shear modulus for the small H/d regime,

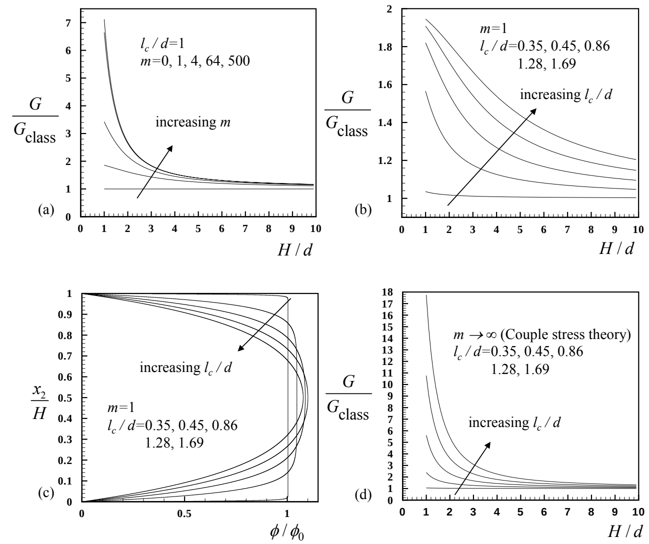

Fig. 9. (a) G/G_{class} plotted against H/d for fixed l_c/d and increasing m. (b) G/G_{class} plotted against H/d for increasing l_c/d and m = 1. (c) Normalized height, x_2/H, plotted against ϕ/ϕ_0, showing the boundary layer for H/d = 10, fixed m and increasing l_c/d. (d) G/G_{class} plotted against H/d, for the couple stress limit ($m \to \infty$) and increasing l_c/d.

for all the microstructures. It is not possible to capture this fluctuation by using a continuum theory. The best that can be done is to fit the average.

Figures 10 to 14 show G/G_{class} versus H/d for the square, perfect hexagonal (default and rotated orientations) and perturbed hexagonal (default and rotated orientations) microstructures, respectively. It is observed that couple stress theory is able to capture the average strengthening effect, but obviously, cannot account for the increasing scatter with decreasing H/d. In addition, especially for the perfect hexagons, we see that the characteristic length associated with the couple stress theory, l_c, is highly dependent on the loading direction. With the increased level of randomness in the microstructure, as in the case of the perturbed hexagons, the effect of the loading direction decreases.

This study shows that the couple stress theory is a good candidate to capture the size effects in shear of cellular solids. Future work will address the question as to whether the optimal coefficients found for shear will also perform well for other loading configurations leading to size effects.

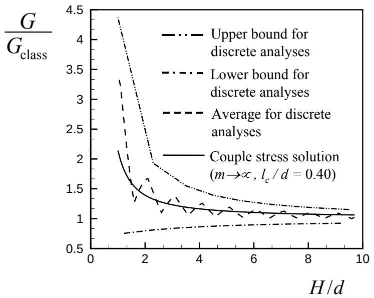

Fig. 10. G/G_{class} plotted against H/d, for the square microstructure.

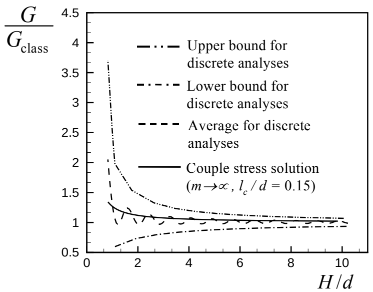

Fig. 11. G/G_{class} plotted against H/d, for the perfect hexagonal microstructure, default orientation.

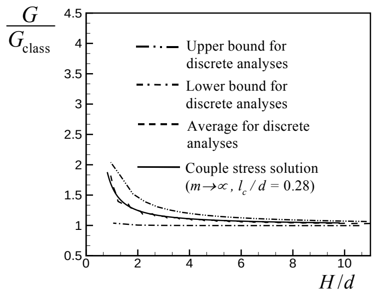

Fig. 12. G/G_{class} plotted against H/d, for the perfect hexagonal microstructure, rotated orientation.

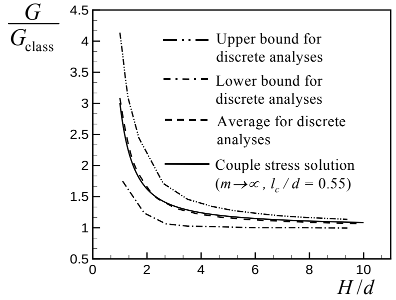

Fig. 13. G/G_{class} plotted against H/d, for the perturbed hexagonal microstructure, default orientation.

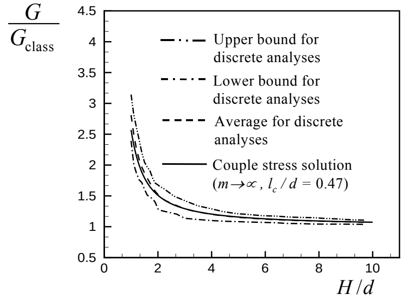

Fig. 14. G/G_{class} plotted against H/d, for the perturbed hexagonal microstructure, rotated orientation.

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Vibrating Grid Turbulence Scaling Laws In Inertial And Rotating Systems

S. Guenther[1], M. Oberlack[1]

S. Guenther won the EUROMECH Young Scientist Prize, awarded at the fifth EUROMECH Fluid Mechanics Conference
Toulouse, August 2003

Almost all flows encountered by engineers in natural or industrial environment are turbulent, resulting in rapid mixing of contaminants introduced into them. Since the turbulent diffusion is much bigger than the molecular diffusion it is an important process that is very efficient at mixing pollutants in the natural environment and thereby reducing the concentrations of potentially harmful contaminants to safe levels. A common civil and environmental application of turbulent diffusion theory is the prediction of the mixing of pollutants in rivers, streams and air. Further the diffusion in estuaries and coastal waters has a number of applications, including the prediction of mixing of wastewater discharges from sewage treatment plants, thermal effluent from power plants, and accidentally released oil spills. To describe the efficiency of turbulent diffusion the mixing of sugar in coffee is regarded. If one puts sugar in the coffee and does not stir it, then the sugar mixes with the coffee only by molecular diffusion, which takes a very long time. On the other hand, if the coffee is stirred, then turbulence is generated inside and turbulent diffusion mixes up the sugar much more efficiently than molecular diffusion. Despite many years of research into turbulent diffusion, it is still poorly understood and can only be rather crudely predicted in many cases.

1. Introduction

To investigate turbulent diffusion it is important to eliminate other influences which affect the flow. Therefore the idealized problem of shear-free turbulent diffusion with no production due to a mean-velocity gradient is reconsidered. Turbulence is generated by a vibrating grid at the plane $x_1 = 0$ and diffuses in the direction $x_1 > 0$. The geometry of the model experiment is given in figure 1.

This problem was first considered by Lele (1985) raising the question whether a turbulent diffusion-wave exists by analysing the k-ε model. Lele used the turbulent diffusion problem as a consistency condition which the model

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constants have to fulfil. Usually model constants are determined by calculating simple wide flows, and then calibrating the model constants to achieve an optimal overall prediction for a class of flows. To make sure that the model constants derived in this manner constitute a consistent set, it is desirable to have additional constraints on the set of model constants. For the present case this additional constraint implies the correct description of the turbulent diffusion and decreasing of the turbulent kinetic energy.

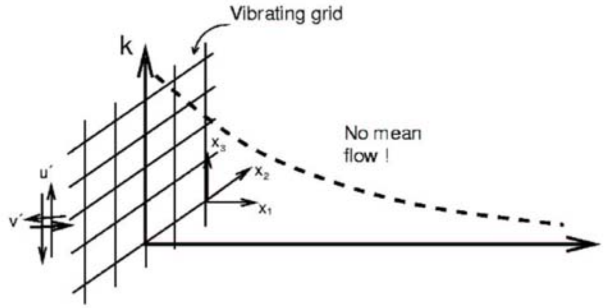

Fig. 1. Flow geometry

In the following we show, based on the Reynolds stress equations, that a variety of invariant solutions (scaling laws, see e.g. Oberlack 2001) of the diffusion problem exist employing Lie-group analysis (see e.g. Bluman & Kumei 1989, Oberlack & Guenther 2003).

2. Symmetries and invariant solutions of the Reynolds stress equations

For the subsequent analysis we employ the Reynolds stress equations.
For a non-rotating frame ($\Omega = 0$) the equations admit the following classical symmetries

$$\overline{T}_{sx} : t^* = t, \quad x_1^* = e^{a_1} x_1, \quad \overline{u_i' u_j'}^* = e^{2a_1} \overline{u_i' u_j'} \qquad (1)$$

$$\overline{T}_{st} : t^* = e^{a_2} t, \quad x_1^* = x_1, \quad \overline{u_i' u_j'}^* = e^{-2a_2} \overline{u_i' u_j'} \qquad (2)$$

$$\overline{T}_{x} : t^* = t, \quad x_1^* = x_1 + a_3, \quad \overline{u_i' u_j'}^* = \overline{u_i' u_j'} \qquad (3)$$

$$\overline{T}_{t} : t^* = t + a_4, \quad x_1^* = x_1, \quad \overline{u_i' u_j'}^* = \overline{u_i' u_j'} \qquad (4)$$

which respectively correspond to scaling of space, scaling of time, translation in space and translation in time.
Depending on the scaling group parameter a_1 and a_2 we can now distinguish three different cases. In the following we employ the abbreviation $n = \frac{a_1}{a_2}$.

2.1 *Turbulent diffusion with spatially growing integral length-scale* ($a_1 \neq 0$, $a_2 \neq 0$)

For the case of no symmetry breaking we receive the following invariant solutions which are taken as the new independent and dependent variables:

$$\widetilde{x}_1 = \frac{x_1 + x_o}{(t+t_o)^{1/n}}, \cdots \overline{u'_i u'_j}(x_1,t) = (x_1 + x_o)^{2(1-n)} \widetilde{\overline{u'_i u'_j}}(\widetilde{x}_1)$$
$$\ell_t(x_1,t) = (x_1 + x_o)\tilde{\ell}_t(\widetilde{x}_1). \tag{5}$$

Here and in the following subsections x_o and t_o are combinations of the a_i. The integral length scale ℓ_t is linearly growing with x_1 independent of n. From experiments we usually have $n = 1.43 \ldots 1.75$ such that $\overline{u'_i u'_j}$ decreases algebraically with the distance from the turbulence source. $\widetilde{x}_1$ is a typical diffusion type of similarity variable such as for the heat equation. For the steady problem i.e. $t \to \infty$ we can show that $\widetilde{\overline{u'_i u'_j}}$ and $\tilde{\ell}_t$ become constants. A sketch of the unsteady and steady self-similar turbulent diffusion according to (5) is given in figure 2.

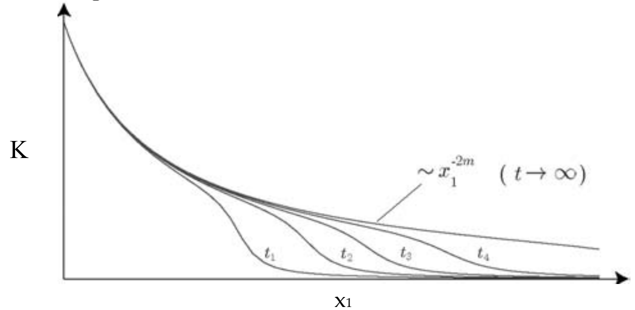

Fig. 2. Sketch of the temporal evolution of the heat-equation-like turbulent diffusion process with spatially growing integral length-scale according to (5).

2.2 *Turbulent diffusion at constant integral length-scale* ($a_1 = 0$, $a_2 \neq 0$)

Since we can derive invariant solutions for arbitrary a_i we may also impose certain symmetry breaking constraints. For the present case we impose $a_1 = 0$, which according to (1), corresponds to the symmetry breaking of scaling of space or in other words $a_1 = 0$ amounts to a constant integral length-scale. Under this constraint we obtain

$$\widetilde{x}_1 = x_1 - x_o \ln(t + t_o), \quad \overline{u'_i u'_j}(x_1,t) = e^{-2\frac{x_1}{x_o}} \widetilde{\overline{u'_i u'_j}}(\widetilde{x}_1)$$
$$\ell_t(x_1,t) = \tilde{\ell}_t(\widetilde{x}_1). \tag{6}$$

Equation (6) implies two important results. Due to the symmetry breaking, e.g. imposed by periodic boundary conditions in the x_2-x_3-plane, a diffusion-wave is induced with decreasing amplitude in the x_1-direction and decreasing wave speed proportional to $1/t$. Second, the spatial decay has changed from algebraic behaviour to exponential, and the integral length-scale becomes constant in space for $t \to \infty$. A sketch of the diffusion wave and the corresponding long-time behavior is depicted in fig. 3.

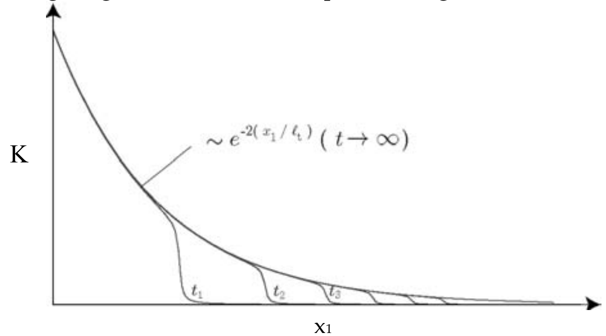

Fig. 3. Sketch of the temporal evolution of the turbulent diffusion wave at constant integral length-scale according to (6).

2.3 *Turbulent diffusion in a constantly rotating frame* ($a_1 \neq 0$, $a_2 = 0$)

In contrast to the previous case we now consider the symmetry breaking of scaling of time $a_2 = 0$ imposed by an external time scale due to frame rotation ($\tau = 1/|\Omega|$). In this case we find

$$x_1 = (x_1 + x_o)^{-\frac{t}{t_o}}, \quad \overline{u'_i u'_j}(x_1,t) = (x_1 - x_0)^2 i\overline{u'_i u'_j}(\widetilde{x}_1)$$
$$\ell_t(x_1,t) = (x_1 - x_0)\tilde{\ell}_t(\widetilde{x}_1). \tag{7}$$

As can be seen in figure 4, any turbulence quantity approaches zero as $x_1 = x_0$. Due to physical reasons an increase in the turbulent kinetic energy K has to be excluded if there is no additional energy source at $x_1 > x_0$. The surprising result for this case is that even for $t \to \infty$ the turbulent diffusion only influences a finite domain due to the quadratic behaviour of the large-scale turbulence quantities.

3. Model implications

Classical two-equation models such as the k-ε and Reynolds-stress transport models were investigated for their capability to capture one or several of the above solutions. If only one-dimensional and time-dependent diffusion is considered we find that for the generic case of no symmetry breaking the value of n, which determines the spatial decay and the temporal behaviour in (5), is determined by a quadratic

$$(12\sigma_K - 6c_{\varepsilon_2}\sigma_\varepsilon)n^2 + (12c_{\varepsilon_2}\sigma_\varepsilon - 17\sigma_K)n - 6(c_{\varepsilon_2}\sigma_\varepsilon + \sigma_K) = 0$$

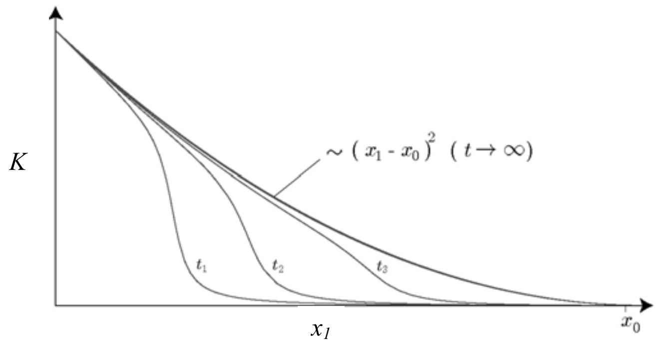

Fig. 4. Sketch of the temporal evolution of the turbulent diffusion on a finite domain at a constant integral time-scale due to rotation according to (7).

and a quartic equation (too long to be presented here) derived from the classical k-ε and the Launder-Reece-Rodi model (Launder 1975) respectively. From the standard model constants we find that only one value for n is meaningful for each model.

The second case where the symmetry breaking of scaling of space is imposed, i.e. when a constant integral length-scale is considered, a solution is only admitted if the model constants are modified. For example, implementing (6) into the K-ε model, the model constants need to obey the equation

$$\frac{c_{\varepsilon_2}\sigma_\varepsilon}{\sigma_K} = 2. \tag{8}$$

The corresponding polynomial equations from the LRR model is given by

$$\begin{aligned}&(3c_1^2c_\varepsilon^2 - 12c_1c_\varepsilon^2 - 8c_1c_\varepsilon c_s c_{\varepsilon_2} + 112c_s c_\varepsilon c_{\varepsilon_2} - 144c_s^2 c_{\varepsilon_2}^2) * \\ &(9c_1^2c_\varepsilon^2 - 12c_1c_\varepsilon^2 - 104c_1c_\varepsilon c_s c_{\varepsilon_2} + 112c_s c_\varepsilon c_{\varepsilon_2} + 144c_s^2 c_{\varepsilon_2}^2) = 0.\end{aligned} \tag{9}$$

Again we see at least for the LRR model that due to the two large factored terms different model parameters lead to multiple, here exponential, solutions. It is important to note that for a given set of model constants only one solution type is admissible, either the algebraic solution (5) or the exponential solution (6). Note that the classical model constants do not solve the above equations (8) and (9). Hence, a one-dimensional solution in the form of an exponential spatial decay is not admitted.

The third case of a rotating frame, e.g. rotating about x_1, cannot be modelled at all by one-point models. Classical linear two-equation models are insensitive to rotation. However, even fully non-linear Reynolds-stress transport models are insensitive to rotation about x_1 for the present flow, elucidating a serious shortcoming of these models.

4. Summary and conclusions

A set of three different invariant solutions for the turbulent diffusion problem has been constructed based on Lie group analysis of the multi-point correlation equations. The solutions cover classical diffusion-like behaviour (heat equation like) with algebraic spatial decay, decelerating diffusion-wave behaviour with exponential spatial decay, and finite domain diffusion due to rotation. Two-equation model equations and full Reynolds stress equations have been investigated to determine whether they capture any of the invariant solutions. Particularly the classical K-ε and the LRR model have been investigated. All models comply with the diffusion-like solution with algebraic spatial decay. The decay exponent is determined by the model constants while multiple decay exponents are observed. The exponential solution is only admitted by the model equations if model constants obey certain algebraic relations. For a given set of model constants either the algebraic or the exponential solution is admitted. None of the classical models is sensitive to rotation for the present diffusion problem and hence the last solution of diffusion on a finite domain is not admitted by any of the turbulence models. The only exception might be the model by Sjögren & Johansson 2000.

For the set of classical model constants only the algebraic solution is obtained. Nevertheless, we may not conclude from the one-dimensional case that with the classical model constants exponential solutions are not admitted for the two- or three-dimensional case. In fact, it appears to be very likely that these solutions exist for probably all Reynolds stress models at dimensions higher than one.

The case of turbulent diffusion with rotation is very difficult. It may only be modelled with a new model equation which is fully non-linear in the mean-velocity gradient. A new model development appears to be necessary and may be along the lines of the model by Sjögren & Johansson.

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EUROMECH

European Mechanics Society

EUROMECH Fellow

The EUROMECH - European Mechanics Society Council has the pleasure to announce the introduction of the category of **EUROMECH Fellow**, starting in 2005. The status of Fellow is awarded to members who have contributed significantly to the advancement of mechanics and related fields. This may be through their original research and publications, or their innovative contributions in the application of mechanics and technological developments, or through distinguished contribution to the discipline in other ways.
Election to the status of Fellow of EUROMECH - European Mechanics Society will take place in the year of the appropriate EUROMECH Conference, EFMC or ESMC respectively, and is limited in total (fluids and solids together) to no more than one-half of one percent of the then current membership of the Society.

Nomination conditions:

• The nomination is made by **two sponsors** who must be members of the Society;

• Successful nominees must be members of the Society;

• Each nomination packet must contain a **completed Nomination Form, signed by the two sponsors, and no more than four Supporting Letters** (including the two from the sponsors)

Nomination Process:

• The nomination packet (nomination form and supporting letters) must be submitted before 15 January in the year of election to Fellow (the year of the respective EFMC or ESMC);

• Nominations will be reviewed before the end of February by the **EUROMECH Fellow Committee**;

• Final approval will be given by the **EUROMECH – European Mechanics Society Council** during its meeting in the year of election to Fellow;

• Notification of newly elected Fellows will be made in May following the Council meeting;

• The Fellow award ceremony will take place during the EFMC or ESMC as appropriate.

Required documents and how to submit nominations: Nomination packets need to be sent before the deadline (before 15 January of the year of the respective EFMC or ESMC) to the President of the Society. Information can be obtained from the EUROMECH web page **www.euromech.org** and the Newsletter. Nomination Forms can also be obtained from the web page or can be requested from the Secretary-General.

EUROMECH - European Mechanics Society

NOMINATION FORM FOR FELLOW

NAME OF NOMINEE:……….....…………………………………………………….…

OFFICE ADDRESS:…………………….…………………………………………...

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EMAIL ADDRESS:………..……………………………………………………..

FIELD OF RESEARCH: …………………………………………………………..

Fluids: ☐ Solids: ☐

NAME OF SPONSOR 1: ..……….....……………………………………………

OFFICE ADDRESS:…………………….……………………………………...…

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EMAIL ADDRESS:…………………………………………………………………

SIGNATURE & DATE: ……………………………………………………………

NAME OF SPONSOR 2: ..……….....…………………………………………….

OFFICE ADDRESS:………..………..………………………………..……...….

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EMAIL ADDRESS:…………………………………………………………………….

SIGNATURE & DATE: …………………………………………………………….

SUPPORTING DATA

- SUGGESTED CITATION TO APPEAR ON THE FELLOWSHIP CERTIFICATE (30 words maximum)
- SUPPORTING PARAGRAPH ENLARGING ON THE CITATION, INDICATING THE ORIGINALITY AND SIGNIFICANCE OF THE CONTRIBUTIONS CITED (limit 250 words)
- NOMINEE’S MOST SIGNIFICANT PRINCIPAL PUBLICATIONS (list at most 8)
- NOMINEE’S OTHER CONTRIBUTIONS (invited talks, patents, professional service, teaching etc. List at most 10)
- NOMINEE’S ACADEMIC BACKGROUND (University Degrees, year awarded, major field)
- NOMINEE’S EMPLOYMENT BACKGROUND (position held, employed by, duties, dates)

SPONSORS DATA

Each sponsor (there are two sponsors) should sign the nomination form, attach a letter of recommendation and provide the following information:

- sponsor’s name
- professional address
- email address
- sponsors signature/date

ADDITIONAL INFORMATION

Supporting letters (no more than four including the two of the sponsors).

Send whole nomination packet to:
Professor Patrick Huerre
President EUROMECH
Laboratoire d’Hydrodynamique, École Polytechnique
91128 Palaiseau Cedex, France
E-mail: huerre@ladhyx.polytechnique.fr

Regulations and Call for Nominations

EUROMECH Fluid Mechanics Prize
EUROMECH Solid Mechanics Prize

The *Fluid Mechanics Prize* and the *Solid Mechanics Prize* of EUROMECH, the European Mechanics Society, shall be awarded on the occasions of Fluid and Solid conferences for outstanding and fundamental research accomplishments in Mechanics.
Each prize consists of 5000 Euros. The recipient is invited to give a Prize Lecture at one of the European Fluid or Solid Mechanics Conferences.

Nomination Guidelines:
A nomination may be submitted by any member of the Mechanics community. Eligible candidates should have undertaken a significant proportion of their scientific career in Europe. Self-nominations cannot be accepted.
The nomination documents should include the following items:

- a presentation letter summarizing the contributions and achievements of the nominee in support of his/her nomination for the Prize,
- a curriculum vitae of the nominee,
- a list of the nominee's publications,
- at least two letters of recommendation.

Five copies of the complete nomination package should be sent to the Chair of the appropriate Prize Committee, as announced in the EUROMECH Newsletter and on the Society's Web site www.euromech.org Nominations will remain active for two selection campaigns.

Prize committees:
For each prize, a Prize Committee, with a Chair and four additional members shall be appointed by the EUROMECH Council for a period of three years. The Chair and the four additional members may be re-appointed once. The committee shall select a recipient from the nominations. The final decision is made by the EUROMECH Council.
Nomination Deadline for the Fluid Mechanics prize: **15 January 2006**.
The members of the *Fluid Mechanics Prize and Fellowship Committee* are:

- D. Abrahams
- H.H. Fernholz (Chair)
- P. Huerre
- D. Lohse

- W. Schröder

Nomination Deadline for the Solid Mechanics prize: **15 January 2006**.

The members of the *Solid Mechanics Prize and Fellowship Committee* are:

- A. Benallal
- I. Goryacheva
- H.M. Jensen
- F.G. Rammerstorfer (Chair)
- B. A. Schrefler

Chairmen's Addresses:

Professor H.H. Fernholz (Chair, Fluids)
Hermann-Föttinger-Institut für Strömungsmechanik
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Professor F.G. Rammerstorfer (Chair, Solids)
Institute of Lightweight Structures and Aerospace Engineering
Vienna University of Technology
Gusshaussstrasse 25-29/317
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Fax : +43-1-58801-31799
Email: ra@ilfb.tuwien.ac.at

Announcement
5th EUROMECH Nonlinear Dynamics Conference
ENOC-2005

7–12 August 2005
Eindhoven University of Technology, The Netherlands
http ://www.enoc2005.tue.nl

The Fifth EUROMECH Nonlinear Dynamics Conference (abbreviated as ENOC-2005) will be held at the Eindhoven University of Technology in The Netherlands from 7–12 August 2005.
The present ENOC Conferences aim to cover the entire field of Nonlinear Dynamics, including Multibody Dynamics and couplings to Control and to Optimization.
In comparison with previous ENOC Conferences the structure of ENOC-2005 has been changed to a far-reaching extent. As usual, a limited number of General Lectures will be delivered by renowned scientists in different sub-fields of Nonlinear Dynamics. However, in addition, a substantial number of minisymposia on major and challenging topics will be organized by recognized scientists, acting also as chairpersons of these minisymposia.

General Lecturers :

- Prof. Thor Fossen (Norway)
- Prof. Jacques Laskar (France)
- Prof. Mark Levi (USA)
- Dr. Leo Maas (The Netherlands)
- Prof. Gábor Stépán (Hungary)
- Prof. Jon Juel Thomsen (Denmark)

More information can be found on the ENOC-2005 website, which will be updated regularly. Alternatively, information is also available at the ENOC-2005

Conference Secretariat e-mail**: enoc2005@tue.nl**

Announcement
8th EUROMECH-MÉCAMAT Conference – EMMC8

Material and structural identification from full-field measurements
13–15 September 2005
École normale supérieure de Cachan, France
http://www.lmt.ens-cachan.fr/emmc8

The mechanics of materials and structures, in its continuing effort towards a better understanding of the relationship between microscopic mechanisms governing macroscopic material behavior and structural response, attempts to find new answers by using full-field measurements and associated inverse and/or multiscale analyses. Nowadays, full-field measurement techniques are often used in universities as well as industrial laboratories. In experiments, in addition to mechanics, physics is involved in optical techniques (e.g., holographic interferometry, speckle interferometry, speckle photography, moiré technique, image correlation), infrared thermography, acoustic emission, X-Ray (micro)-tomography, or particle accelerometers (e.g., neutrons). The researcher or the engineer has access to huge amounts of experimental data (e.g., up to a few millions of displacement vectors). This information requires ad hoc data processing as opposed to classical methods that deal with a few measurements. Full-field measurements also allow for identifications of linear and non-linear constitutive equations for heterogeneous physical and mechanical fields in the presence of damage attracted phenomena. The purpose of the meeting is to bring together specialists in the development of experimental techniques, in use in the mechanics of materials and structures. Various aspects such as the following are concerned :

– recent developments of the experimental techniques in relationship with mechanical applications, combination of different measurement techniques ;
– new experimental strategies using full-field measurement techniques ;
– multiscale experimental characterization (for any type of material or the loading conditions) ;
– new inverse analyses or identification techniques using full-field measurements.

Attention will be focused on the interaction between general fundamental concepts, experimental techniques and specific applications to different material fields such as :

– multiscale description of physical and mechanical properties ;
– non-linear constitutive equations ;
– continuum damage mechanics and fracture mechanics.

Co-Chairmen : O. Allix, Y. Berthaud, F. Hild (Cachan) and G. Maier (Milan)
Web: **http://www.lmt.ens-cachan.fr/emmc8**
E-mail**: claudine.chabaud@lmt.ens-cachan.fr**

First Announcement
9th EUROMECH-MÉCAMAT Conference – EMMC9

Local approach to fracture
9–12 May 2006
Moret Sur Loing, France
http://www.mat.ensmp.fr/EMMC9

This conference is the ninth in a new series of European Mechanics of Materials Conferences to be held under the auspices of the European Mechanics Society and the French Society for Mechanics of Materials. These EUROMECH-MÉCAMAT Conferences continue the tradition of past MECAMAT International Seminars.
The purpose of the meeting is to bring together specialists of experimental, modeling and simulation techniques devoted to the analysis of macroscopic fracture based on the description of microscopic mechanisms. Various aspects such as the following are concerned:
* Ductile fracture of metals,
* Brittle fracture of metals,
* Ductile to brittle transition,
* Creep rupture,
* Fracture of polymers and elastomers,
* Experimental fracture mechanics,
* Constitutive models,
* Micromechanical modelling,
* Scale effects,
* Computational fracture mechanics.
* Load history effect (WPS, …).
The Conference will include presentation in oral or poster form. Abstracts of about 500 words are invited before September 1, 2005. They should contain the title of the communication, full names and addresses of the authors, objectives of the study, methods employed, and the most significant results. Submission of the abstract by e-mail (PDF format) is recommended. Notification of acceptance will be sent to authors by December 15, 2005. A six-page paper will be **due before March 15, 2006**. Copies of all these papers will be available in book-form as pre-prints of the proceedings, on the first day of the conference. Full size refereed papers will be published later as a special issue of Engineering Fracture Mechanics. These papers should be sent before December 31, 2006. Instructions concerning the format of the papers will be available on the conference web page.

Co-Chairmen : J. Besson, D. Steglich, D. Moinereau
Conference Secretariat: V Diamantino
E-mail**:** emmc9@mat.ensmp.fr

Announcement
6th European Fluid Mechanics Conference – EFMC6

26–30 June 2006
KTH, Stockholm, Sweden
http://www2.mech.kth.se/efmc6/

The 6th European Fluid Mechanics Conference, organized by EUROMECH (the European Mechanics Society), will take place at KTH, Royal Institute of Technology, Stockholm, 26–30 June 2006.

The conference aims to provide an international forum for the exchange of information on all aspects of fluid mechanics, including instability and transition, turbulence, multiphase and non-Newtonian flows, bio-fluid mechanics, reacting and compressible flows, numerical and experimental methods, geophysical flows etc., as well as all types of fluid mechanics applications.

Eight prominent scientists have already accepted the invitation to give keynote lectures in their respective fields of expertise. These are (in alphabetical order):
– Gustav Amberg (Sweden) - Fluid mechanics of phase change
– Stephan Fauve (France) - Generation of magnetic fields by turbulent flows of liquid metals
– Sascha Hilgenfeldt (USA) - The power of bubbles: Unconventional micro-fluidics
– Rich Kerswell (UK) - Progress in Reynolds' problem: transition to turbulence in pipe flow
– Hilary Ockendon (UK) - Continuum models in industrial applications
– Norbert Peters (Germany) - Combustion
– Jens Sørensen (Denmark) - Wind turbine wake structures
– Sandra M. Troian (USA) - Microfluidic actuation and sensing for open architecture systems: Fundamentals to applications.

In addition to these 8 invited lectures and one lecture by the EUROMECH Fluid Mechanics Prize winner (not yet selected), contributions are solicited from the worldwide fluid mechanics research community. The paper selection will be made by the EUROMECH Fluid Mechanics Conference Committee on the basis of the extended abstracts submitted at the end of 2005 (details on the submission process will be given on the conference home-page during Spring/Summer 2005). For further information please visit the above website.

Enquiries should be sent to **efmc6@mech.kth.se**

Announcement
6th European Solid Mechanics Conference – ESMC6

28 August - 1 September 2006
Budapest University of Technology and Economics
Budapest, Hungary
http://esmc2006.mm.bme.hu

The 6th European Solid Mechanics Conference (ESMC 2006) will be held at the Budapest University of Technology and Economics (BME), Hungary, 28 August -- 1 September, 2006 under the auspices of the European Mechanics Society (EUROMECH).

The conference aims to provide an international forum for the exchange of information on all aspects of solid mechanics, including Continuum Mechanics
(*General theories, Elasticity, Plasticity, Multi-field problems*), Materials Mechanics (*Damage and fracture, Viscoelastic materials and systems, Composites, Contact problems*), Structural Mechanics (*Beam structures, Plates and shells, Stability, Structural optimization*), Dynamics (*Kinematics, Multibody systems, Vibrations, Nonlinear dynamics*), Computational and experimental methods

The following scientists have already accepted the invitation to give keynote lectures in their respective fields of expertise:
– Werner Schielen (Universität Stuttgart, Germany) - Dynamics
– Gerhard A. Holzapfel (KTH Stockholm, Sweden) - Biomechanics
– Jean-Jacques Marigo (Université Paris 13, France) - Fatigue/Fracture
– Paul van Houtte (KU Leuven, Belgium) - Plasticity/Damage
– Alexander B. Movchan (University of Liverpool, UK) - Stability
– Nikita Morozov (St. Petersburg State University, Russia) - Micromechanics
– Dick van Campen (Eindhoven, The Netherlands) - Nonlinear Dynamics

In addition to these invited lectures and one lecture by the EUROMECH Solid Mechanics Prize winner (not yet selected), contributions are solicited from the worldwide solid mechanics research community. The paper selection will be made by the EUROMECH Solid Mechanics Conference Committee on the basis of the extended abstracts submitted before 15 November 2005 (details on the submission and registration process are given on the conference home-page). For further information please visit the above website.

Enquiries should be sent to **esmc2006@mm.bme.hu**

Announcement and Call for Papers
11th EUROMECH European Turbulence Conference
ETC11

25–28 June 2007
Faculty of Engineering of the University of Porto, Portugal
http://www.fe.up.pt/etc11

The 11th EUROMECH European Turbulence Conference (ETC11), organized by the EUROMECH - European Mechanics Society, will take place at the Faculty of Engineering of the University of Porto (FEUP) in Porto, Portugal.
The conference aims to provide an international forum for exchange of information on most fundamental aspects of turbulent flows, including instability and transition, intermittency and scaling, vortex dynamics and structure formation, transport and mixing, turbulence in multiphase and non-Newtonian flows, reacting and compressible turbulence, acoustics, control, geophysical and astrophysical turbulence, and large-eddy simulations and related techniques, MHD turbulence and atmospheric turbulence.
Following the established tradition, the conference programme will comprose 8 invited talks (two per day), selected papers and posters sessions.
Contributions are solicited from the worldwide turbulence research community.
The paper selection will be made by the EUROMECH Turbulence Conference Committee on the basis of two-page abstracts submitted via the conference webpage, at **www.fe.up.pt/etc11** by 6 October 2006.
All accepted papers and posters will appear in a conference proceedings to be distributed among the participants. A smaller set of papers may be published after the conference in a special issue of a scientific journal. For further information and updates please visit the conference website or contact the organizers at **etc11@fe.up.pt**.

EUROMECH Conferences in 2005, 2006 and 2007

The general purpose of EUROMECH conferences is to provide opportunities for scientists and engineers from all over Europe to meet and to discuss current research. Europe is a very compact region, well provided with conference facilities, and this makes it feasible to hold inexpensive meetings.
The fact that the EUROMECH Conferences are organized by Europeans primarily for the benefit of Europeans should be kept in mind. Qualified scientists from any country are of course welcome as participants, but the need to improve communications within Europe is relevant to the scientific programme and to the choice of leading speakers.
A EUROMECH Conference on a broad subject, such as the ESMC or the EFMC, is not a gathering of specialists all having the same research interests, and much of the communication which takes place is necessarily more in the nature of the imparting of information than the exchange of the latest ideas. A participant should leave a Conference knowing more and understanding more than on arrival, and much of that gain may not be directly related to the scientist's current research. It is very important therefore that the speakers at a Conference should have the ability to explain ideas in a clear and interesting manner, and should select and prepare their material with this expository purpose in mind.

ENOC5
5th EUROMECH Nonlinear Dynamics Conference
DATES: 7 – 12 August 2005
LOCATION: Auditorium Building, Eindhoven University of Technology, The Netherlands
CONTACT: Dick H. van Campen, Dept. Mechanical Engineering, Eindhoven University of Technology, P.O. Box 513, 5600 MB Eindhoven, The Netherlands
EMAIL: D.H.v.Campen@tue.nl , FAX: +31 40 243 7175
WEBSITE: http://www.enoc2005.tue.nl

EMMC8
8th EUROMECH-MÉCAMAT Conference
DATES: 13 – 15 September 2005
LOCATION: ENS Cachan, Avenue du President Wilson 61, Cachan, France
CONTACT: Claudine Chabaud
EMAIL: chabaud@lmt.ens-cachan.fr
PHONE: +33 1 47 40 22 39
WEBSITE: http://www.lmt.ens-cachan.fr/emmc8

EMMC9
9th EUROMECH-MÉCAMAT Conference
DATES: 9-12 May 2006
LOCATION: Moret Sur Loing, France
CONTACT: Jacques Besson, Ecole Nationale des Mines de Paris, France
E-MAIL: jacques.besson@ensmp.fr
WEBSITE: http://www.mat.ensmp.fr/EMMC9/

EFMC6
6th European Fluid Mechanics Conference
DATES: 26 – 30 June 2006
LOCATION: KTH, Stockholm, Sweden
CONTACT: efmc6@mech.kth.se
WEBSITE: http://www2.mech.kth.se/efmc6/

ESMC6
6th European Solid Mechanics Conference
DATES: 28 August - 1 September 2006
LOCATION: Budapest University of Technology and Economics (BUTE), Budapest, Hungary
CONTACT: Prof. Gábor Stépán – chairman; Dr. Ádám Kovács – secretary, BUTE Department of Applied Mechanics, 1521 Budapest, P.O. Box 91
Fax: +36 1 463 3471
E-MAIL: esmc2006@mm.bme.hu
WEBSITE: http://esmc2006.mm.bme.hu

EETC11
11th EUROMECH European Turbulence Conference
DATES: 25 – 28 June 2007
LOCATION: Faculty of Engineering of the University of Porto
Porto, Portugal
CONTACT: etc11@fe.up.pt.
WEBSITE: http://www.fe.up.pt/etc11

Euromech colloquia in 2005 and 2006

EUROMECH Colloquia are informal meetings on specialized research topics. Participation is restricted to a small number of research workers actively engaged in the field of each Colloquium. The organization of each Colloquium, including the selection of participants for invitation, is entrusted to a Chairman. Proceedings are not normally published. Those who are interested in taking part in a Colloquium should write to the appropriate Chairman. Number, Title, Chairperson or Co-chairperson, Dates and Location for each Colloquium in 2005, and preliminary information for some Colloquia in 2006, are given below.

EUROMECH Colloquia in 2005

461. Vortex and Magnetohydrodynamics - Structure, Symmetry and Singularity - Cancelled

462. Fluid Mechanical Stirring and Mixing - Cancelled

463. Size-dependent Mechanics of Materials
Chairman: Prof. P.R. Onck, University of Groningen, Micromechanics of Materials, Nijenborgh 4, 9747 AG Groningen, The Netherlands
Phone: +31 50 363 8039
Fax: +31 50 363 4886
E-mail: p.r.onck@phys.rug.nl
Co-chairman: Prof. Dr. T. Pardoen, Université Catholique de Louvain, Materials Science and Processes Department, PCIM, Bâtiment Réaumur, Place Sainte Barbe 2, B-1348 Louvain-la-Neuve, Belgium
Euromech contact person: Prof. E. van der Giessen
Date and location: 13–16 June 2005, Groningen, The Netherlands
http://mm03.phys.rug.nl/~onck/Euromech-Colloquium-463.htm

464b. Wind energy
Chairman: Prof. Dr. Peinke, Center for Wind Energy Research, Carl von Ossietzky University of Oldenburg, Faculty V, Institute of Physics, 26111 Oldenburg, Germany
Phone: +49 441 798 3536
Fax: +49 441 798 3990
E-mail: peinke@uni-oldenburg.de
Co-chairman: Prof. Dr.-Ing. Schaumann, University of Hannover, Institute for Steel Construction, Appelstrasse 9a, 30167 Hannover, Germany
Euromech contact person: Prof. Hans Fernholz
Date and location: 4–7 Octobre 2005, Oldenburg
http://www.forwind.de/euromech

465. Hydrodynamics of Bubbly Flows
Chairman: Professor Dr. Detlef Lohse, Applied Physics, University of Twente, Postbus 217, 7500 AE Enschede, The Netherlands
Phone: +31 534 898 076
Fax: +31 534 898 068
E-mail: d.lohse@utwente.nl
Co-chairman: Prof. Leen van Wijngaarden, Impact Institute, University of Twente, Postbus 217, 7500 AE Enschede, The Netherlands
Euromech contact person: Prof. Hans Fernholz
Date and location: 6–8 June 2005, Lorenz Center Leiden, The Netherlands

466. Computational and Experimental Mechanics of Advanced Materials 2005
Chairman: Professor Vadim V. Silberschmidt, Wolfson School of Mechanical and Manufacturing Engineering, Loughborough University, Ashby Road, Loughborough, Leics., LE11 3TU, UK
Phone: +44 1509 227504
Fax: +44 1509 227502
E-mail: v.silberschmidt@lboro.ac.uk
Co-chairman: Prof. Ewald Werner, Lehrstuhl Werkstoffkunde und Werkstoffmechanik, Technische Universität München, Germany
Co-chairman: Prof. Helmut Böhm, Institute of Lightweight Design and Structural Biomechanics, TU Wien, Austria
Euromech contact person: Prof. Ahmed Benallal
Date and location: 20–22 June 2005, Loughborough, UK
http://www.lboro.ac.uk/departments/mm/conferences/ec466/

467. Turbulent Flow and Noise Generation
Chairman: Prof. Dr. rer. nat. Claus-Dieter Munz, Institut für Aerodynamik und Gasdynamik, Pfaffenwaldring 21, 70550 Stuttgart, Germany
Phone: +49 711 685 3433
Fax: +49 711 685 3438
E-mail: munz@iag.uni-stuttgart.de
Co-chairman: Prof. Dr. Patrick Bontoux, Université de Provence, Marseille, France
Euromech contact person: Prof. Wolfgang Schröder
Date and location: 18–20 July 2005, Université de Provence, Marseille, France
http://www.iag.uni-stuttgart.de/Euromech-467/

468. Multi-scale Modelling in the Mechanics of Solids
Chairman: Acad. N.F. Morozov, Institute for Problems in Mechanical Engineering, Russian Academy of Sciences
Phone: +7 812 321 4788
Fax: +7 812 321 4771
E-mail: morozov@nm1016.spb.edu
Co-chairperson: Acad. Irina G. Goryacheva, Institute for Problems in Mechanics, Russian Academy of Sciences
Co-chairperson: Prof. M. Wiercigroch, University of Aberdeen, UK
Euromech contact person: Acad. Irina Goryacheva
Date and location: 29 June – 1 July 2005, St. Petersburg, Russia
http://www.ipme.ru/ipme/conf/apm2005/euromech/

469. LES of Complex Flows
Chairman: Prof. Dr. N. Adams, Technische Universität Dresden, Institut für Strömungsmechanik, George-Bähr-Str. 3c, 01062, Dresden, Germany
Phone: +49 351 463 37607
Fax: +49 351 463 35246
E-mail: nikolaus.adams@ism.mw.tu-dresden.de
Co-chairman: Dr. habil. M. Manhart, Lehrstuhl für Fluidmechanik, Technische Universität München, Boltzmannstrasse 15, 85748 Garching, Germany
Euromech contact person: Prof. Hans Fernholz
Date and location: 6–9 October 2005, Dresden, Germany
http://www.tu-dresden.de/mw/ism/euromech/

471. Turbulent Convection in Passenger Compartments
Chairman: Dr. C. Wagner, DLR Göttingen, Bunsenstrasse 10, 37073 Göttingen, Germany
Phone: +49 551 709 2261
Fax: +49 551 709 2404
E-mail: claus.wagner@dlr.de
Co-chairman: Prof. A. Thess, Technical University of Ilmenau, Germany
Euromech contact person: Prof. Wolfgang Schröder
Date and location: 13-14 October 2005, Göttingen, Germany
http://www.dlr.de/as/institut/abteilungen/abt_ts/arbeitsgebiete/euromech471

472. Microfluidics and Transfer
Chairman: Prof. Michel Favre-Marinet, LEGI BP 53, 38041 Grenoble cedex, France
Phone: +33 4 7682 5049
Fax: +33 4 7682 5271
E-mail: michel.favre-marinet@hmg.inpg.fr

Co-chairman: Dr. Patrick Tabeling, MMN ESPCI, 24, rue Lhomond, 75231 Paris cedex 05, France
Euromech contact person: Prof. Emil Hopfinger
Date and location: 6–8 September 2005, Grenoble, France
http://www.legi.hmg.inpg.fr/microfluidics2005/

473. Failure and Fracture of Composite Materials
Chairman: Prof. A.T. Marques, Departamento de Engenharia Mecânica e Gestão Industrial, Faculdade de Engenharia da Universidade do Porto, Rua Dr. Roberto Frias, s/n, 4200 - 465 Porto, Portugal
Phone: +351 22 508 1716
Fax: +351 22 508 1584
E-mail: marques@fe.up.pt
Co-chairman: Prof. A.M. Balaco de Morais, Departamento de Engenharia Mecânica, Universidade de Aveiro, Aveiro, Portugal
Co-chairman: Prof. P. T. de Castro, Departamento de Engenharia Mecânica e Gestão Industrial, Faculdade de Engenharia da Universidade do Porto, Porto, Portugal
Euromech contact person: Prof. Jorge Ambrosio
Date and location: 27–29 October 2005, Porto, Portugal
http://paginas.fe.up.pt/~euromech/

474. Material Instabilities in Coupled Problems
Chairman: Prof. A. Benallal, LMT-Cachan, 61 Avenue du Président Wilson, 94235 Cachan, France
Phone: +33 1 47 40 27 39
Fax: +33 1 47 40 22 40
E-mail: benalla@lmt.ens-cachan.fr
Co-chairman: Prof. D. Bigoni, Trento University, Italy
Euromech contact person: Prof. Patrick Huerre
Date and location: 30 August – 1 September 2005, Troyes, France
http://afm.crihan.fr/1107513095590/0/fiche___actualite/

EUROMECH Colloquia in 2006

470. Recent Development in Magnetic Fluid Research
Chairman: Dr. Stefan Odenbach, ZARM, University of Bremen, Am Fallturm, D-28359, Bremen, Germany
Phone: +49-(0)421 2184 785, Fax: +49-(0)421 2182 521
E-mail: odenbach@zarm.uni-bremen.de
Co-chairman: Prof. Dr. Elmars Blums, Institute of Physics, University of Latvia, Salaspils, Latvia
Euromech contact person: Prof. Wolfgang Schröder

Date and location: 27 February-1 March 2006, Dresden, Germany
http://www.zarm.uni-bremen.de/2forschung/ferro/conferences/Euromech06/euromech_colloquium_470.htm

475. Fluid Dynamics in High Magnetic Fields
Chairman: Prof. A. Thess, Department of Mechanical Engineering, Ilmenau, University of Technology, P.O. Box 100 565, D-98684, Ilmenau, Germany
Phone: +49-(0)3677 69 2445, Fax: +49-(0)3677 69 1281
E-mail: thess@tu-ilmenau.de
Date and location:1-3 March 2006, Ilmenau, University of Technology, Germany
http://www4.tu-ilmenau.de/mfd/euromech2006.html

476. Real-time Simulation and Virtual Reality Applications of Multibody Systems
Chairman: Prof. J. Cuadrado, Escuela Politecnica Superior, Universidad de La Coruña, Mendizabal s/n 15403 Ferrol, Spain
Phone: +34-9813 37400 ext. 3873, Fax: +34-9813 37410
E-mail: javicuad@cdf.udc.es
Co-chairman: Prof. W. Schiehlen, Institute B of Mechanics, University of Stuttgart, Germany
Euromech contact person: Prof. Jorge Ambrosio
Date and location: 13-16 March 2006, Ferrol, Spain
http://lim.ii.udc.es/events/euromech476/

477. Particle-laden Flow. From Geophysical to Kolmogorov Scales
Chairman: Prof. B.J. Geurts, Mathematical Sciences, University of Twente, P.O. Box 217, 7500 AE Enschede, The Netherlands
Phone: +31-(0)48 94125, Fax: +31-(0)48 94833
E-mail: b.j.geurts@utwente.nl
Co-chairman: Prof. Dr. H.J.H. Clercx, Eindhoven University of Technology, and Dr. W.S.J. Uijttewaal, Delft University of Technology, The Netherlands.
Euromech contact person: Prof. Detlef Lohse
Date and location: 21-23 June 2006, University of Twente, The Netherlands
http://wwwhome.math.utwente.nl/~geurtsbj/workshops/euromech_477/

EUROMECH CONFERENCE REPORTS

10th EUROMECH European Turbulence Conference

June 29 – July 2, 2004, Trondheim, Norway

Helge I. Andersson[1] & Per-Åge Krogstad[1]

The very first European Turbulence Conference (ETC) was held in Lyon in 1986 and attracted some 150 participants. Since then the biennial series of conferences has been arranged in Berlin, Stockholm, Delft, Siena, Lausanne, Saint-Jean Cap Ferrat, Barcelona and Southampton. The European Turbulence Conferences are devoted to fundamental aspects of the fascinating and intricate physics of fluid turbulence. The organizers strive to provide a meeting place for physicists, mathematicians and engineers.

This time, on the occasion of the tenth ETC, the conference was located on the campus of the Norwegian University of Science and Technology (NTNU) in Trondheim. ETC10 was held from June 29 to July 2, i.e. four full days, and was arranged under the auspices of the European Mechanics Society with support from ERCOFTAC.

Eight prominent scientists, of whom four were from outside Europe, were invited to give 40 minute plenary lectures at ETC10. Moreover, about 330 abstracts were received by the deadline October 31, 2003, of which 77% were accepted for either oral or poster presentation by the ETC Committee at its meeting in January 2004. This acceptance rate is comparable to that for ETC9 (Southampton, 2002) and ETC8 (Barcelona, 2000). Roughly half of the submitted abstracts were accepted for oral presentation. These talks were organized in three parallel sessions and the speakers were allotted 20 minutes each. In addition, about 25% of the submitted abstracts were accepted for poster presentation, and of these 65 posters included in the proceedings the vast majority were displayed at the conference.

The topics addressed by the eight invited speakers are believed to reflect major activities and current focuses within the international turbulence research community. The invited speakers at ETC10 were (in order of appearance):

Y. Kaneda (Nagoya) "High resolution direct numerical simulation of turbulence"

[1] *Department of Energy and Process Engineering, Norwegian University of Science and Technology*

N.D. Sandham (Southampton) "Turbulence simulation for aeroacoustics applications"

Z. Warhaft (Ithaca) "Passive scalar fine scale structure: recent results and implications for the velocity field"

C. Cambon (Lyon) "Nonlinear dynamics and anisotropic structuring in rotating stratified flows"

T.S. Lundgren (Minnesota) "An inertial range scaling law"

S.B. Pope (Ithaca) "Advances in PDF methods for turbulent reactive flows"

G. Boffetta (Torino) "Lagrangian statistics in fully developed turbulence"

D.S. Henningson (Stockholm) "Optimal feedback control applied to boundary layer flow"

The contributed oral presentations were grouped under the following topic headings: wall turbulence (28), vortex dynamics and structure formation (13), control of turbulent flows (18), instability and transition (9), transport and mixing (11), acoustics of turbulent flows (3), intermittency and scaling (21), free shear flows (9), geophysical and astrophysical turbulence (14), large-eddy simulation and related techniques (11), reacting and compressible flows (9), and turbulence in multiphase and non-Newtonian flows (12).

The breadth of problems considered reflects the inherent complexity of turbulent flow phenomena as well as the impact of turbulence on geophysical and industrial fluid dynamics. The number of contributed talks in each subject field (given in parentheses above) may be taken as a first indication of the most popular research areas today. However, many talks could have been classified under more than one topic; e.g. wall turbulence and control of turbulent flows.

All invited lectures (8 pages), oral presentations (4 pages) and posters (1 page) were included in the conference proceedings "*Advances in Turbulence X*" edited by the two organizers. The hardcover book was published by CIMNE and made available to all participants upon arrival. This 880 pages volume can be ordered at http://www.cimne.com/. In addition to the conference proceedings, a collection of carefully selected papers from ETC10 will be published in a special issue of the *Journal of Turbulence*. These include five papers derived from the invited talks and about ten expanded papers based on contributed talks.

The next conference in this successful series of turbulence gatherings will be organized by Professor Jose M.L.M. Palma at **University of Porto** (Portugal) **June 25 – 28, 2007.**

EUROMECH COLLOQUIA REPORTS

EUROMECH Colloquium 424

"Buckling Predictions of Imperfection Sensitive Shells"

2-5 September 2001, ROLDUC, The Netherlands
Chairperson: Prof. Dr. J. Arbocz

The topic of this colloquium received wide interest from those in the scientific community who work in the field of shell stability. Nearly all the major European Research Groups accepted the invitation of the organizers and attended the conference. They presented at least one paper covering the topics of the meeting. In addition, quite a few additional proposals were received, so that an interesting programme (see annex) could be arranged, serving as a basis for the discussion of the main question raised at the conference: "Is it possible to devise an improved shell design procedure, which makes full use of the concept of imperfection sensitivity and the new generation of nonlinear computer codes, as an alternative to the currently used design curves, which are based on lower bounds to all currently available experimental results?"
In summary 39 papers were presented including 5 papers from East-European countries, 1 paper from Israel and 1 from the USA (the papers by M. Jamal et al (Morocco) and J. Naprstek (Czech Repubic) were withdrawn at the last minute for various reasons).

There were a number of survey type lectures covering such topics as

> "On the Imperfection Sensitivity of Shells",
> "Substitute Geometrical Imperfections for the Numerical Buckling Assessment of Cylindrical Shells under Combined Loading",
> "Nonlinear Shell Buckling Design: Examples coming from the Nuclear Industry and Applications to Other Industries"

and another review paper dealing with the different mathematical approaches that have been used to elucidate the perplexing buckling behavior of thin-walled shells.

That the use of assumed or measured initial imperfections has become a standard procedure whenever stability analysis is carried out was vividly demonstrated by the large number of papers dealing with the evaluation of the load carrying capacity of different shell geometries under various external loads. In all cases the imperfection sensitivity of the critical buckling loads was investigated either by using a variety of numerical approaches (e.g. based on Koiter's asymptotic imperfection sensitivity theory), or by employing advanced nonlinear shell codes to calculate the nature of the nonlinear collapse of imperfect shell structures.

There were a number of papers which dealt with the derivation of relatively simple-to-use buckling formulas based on either analytical solutions or on numerical simulations derived from the fully nonlinear theory. Some authors attempted to validate the predictions by comparison with experimental results, others by comparison with the results of refined finite element collapse load calculations.

Several papers discussed plastic buckling and localization of buckling patterns, as well as dynamic buckling. Other presentations dealt with special problems such as the buckling behavior of foam-filled circular cylindrical shells under axial compression, creep buckling of cylindrical shells under axial and radial loads, neutral predictions of buckling loads of cylindrical shells, buckling behavior of high performance concrete shells, the use of buckling and postbuckling characteristics of thin strips to estimate residual stresses and delamination growth analysis of axially compressed composite panels.

Four papers reported on an approach often called "high-fidelity analysis", where the uncertainties involved in design are simulated by refined and accurate numerical models. Two papers used a "hierarchical approach" to investigate possible detrimental consequences of a range of factors such as the effects of stiffeners and load eccentricity and prebuckling deformation caused by the edge restraints, as well as the influence of initial imperfections and of the boundary conditions. The other two papers presented the results of a combined experimental and analytical study of the buckling response of unstiffened thin-walled graphite-epoxy cylindrical shells. It was shown that, by incorporating the traditional initial geometric shell-wall imperfections, as well as other less traditional forms of imperfections (such as shell-wall thickness variations, shell-end imperfections, variations in loads applied to the ends of the shell, variations in boundary conditions and boundary stiffness and the effects of manufacturing anomalies caused by small gaps between adjacent pieces of graphite-epoxy tape in a shell-wall layer), the high-fidelity nonlinear shell analysis procedure will predict the response of the shells quite accurately. Preliminary results of this comparison suggest that the nonlinear analysis procedure can be used for determining accurate, high-fidelity design knockdown factors for predicting shell buckling and collapse in the design process.

It was unfortunate that the only paper dealing with Stochastic Stability Analysis using random initial imperfections had to be withdrawn at the last minute due to personal reasons.

The differences between the two popular approaches to the design of buckling sensitive shell structures, namely the Lower Bound Design based on an empirical knockdown factor versus the Imperfection Sensitivity Design based on worst shape or measured initial imperfections were highlighted by many discussions not only during the sessions but continuing over the common meals, and also until late hours in the friendly bars of the Monastery Congress-

Center Rolduc. After lengthy and lively discussions on the results presented, there emerged a general agreement that if one wants to achieve a reliable prediction of the buckling or collapse load one must work with measured initial imperfections. There was unanimous support for continuing and intensifying imperfection surveys on representative full scale structures. The prevailing opinion was that International Projects supported within the EUROCODE activities of the EC in Brussels should be the appropriate way to proceed with this undertaking.

In conclusion, the Colloquium made it clear that the present level of nonlinear shell theories and their numerical implementations offer ways to model the collapse behavior of shell structures accurately, if the appropriate input data is available. Here it must be stressed that, in addition to the initial geometric imperfections, we may also require information regarding shell end imperfections, variations in loads applied to the ends of the shell and other less traditional imperfections for a reliable and accurate prediction of the buckling load.

Furthermore, in certain applications such as large off-shore drilling-platforms, material nonlinearities must also be modelled accurately in order to reliably predict the collapse load.

The establishment of an International Imperfection Data Bank containing imperfection surveys on representative shell structures and the development of reliability Based Design Procedures will become more important in the coming years. These could be topics for a further colloquium on shell stability analysis in, say, three years time, when the new results obtained with these techniques could be discussed in more detail.

EUROMECH Colloquium 438

"Constitutive Equations for Polymer Microcomposites: On the Border of Mechanics and Chemistry"

15-17 July 2002, Vienna, Austria
Chairperson: Dr. Ing. A. Dorfmann

The main objective of this meeting was to gather specialists in mechanical engineering and polymer science actively working on the analysis of the mechanical response of rubbery polymers and polymeric composites. Our hope was that this interaction of research scientists with different backgrounds would result in a better understanding of the most challenging problems in the area of constitutive modelling and simulation and would lead to further cooperation in their study. The Colloquium was organized into a number of keynote lectures and scientific presentations.

The main areas of the Colloquium and Workshop are summarized as follows:

1. Experimental analysis of the mechanical behaviour
2. Analytical methods in the mechanics of polymers
3. Micromechanical constitutive models
4. Numerical methods and simulation
5. Time-dependent phenomena
6. Fracture and fatigue of polymeric composites
7. Anisotropy of the mechanical response
8. Ageing of rubber compounds
9. Mechanical behaviour of nanocomposites

Keynote Lectures

"Micromechanical Modelling of Particle-Modified Polymeric Materials"

Mary C. Boyce

"Why Do Cracks Turn Sideways?" Alan N. Gent

"A Constitutive Approach to the Modelling of Hysteresis Effects in Rubber-Like Materials Based on Directly Evaluated Micro-to-Macro Transitions" Christian Miehe

"Thermo-Mechanical Response of Elastomers Undergoing Scission and Cross-linking at High Temperatures" Alan Wineman

Suggestions for the future:

The concluding session was jointly chaired by Prof. Boyce from Massachusetts Institute of Technology, Prof. Ogden from the University of Glasgow and Prof. Sternstein from Rensselaer Polytechnic Institute. First, a summary of the presentations was given. From all aspects considered in this concluding session, one should be mentioned in this report. Essentially, there was wide acknowledgment that many models and theories have been developed over the last few years, but no single best viscoelastic model has emerged at this time. Furthermore, the importance and need of additional experimental work in order to validate theories was stressed. It was agreed to encourage a greater interaction of the molecular and chemical communities in order to improve the understanding of the time-dependent behaviour of polymer micro-composites. Finally, it was acknowledged that a stronger interaction between the material science and the mechanical communities should be supported too.

EUROMECH Colloquium 448

"Vortices and Field Interactions"

6-10 September 2004, ESPCI Paris, France
Chairperson: Maurice Rossi

The conference brought together that part of the international community studying flows in which vortices play a major role. Many young researchers attended the meeting. Each participant could give a 15 to 20 minute talk, and twelve invited talks of one hour each were included to introduce the various topics. This structure ensured positive and vivid interactions between all participants, in particular between established scientists and young European researchers. During the meeting, experimental, numerical and theoretical approaches were all considered.

Since vortices are widespread phenomena in nature, the discussion covered various fields: geophysics, aeronautics, turbulence, magneto-hydrodynamics and also classical vortex dynamics. For instance, the interaction between vortices was analyzed in geophysics (e.g. stratified wakes), in aeronautics (aircraft wakes) and in turbulence (coherent structures). Transition to turbulence (instability growth, Couette flow), passive scalar dispersion such as pollutant, plancton dispersion, and the dynamo effect were other themes of the colloquium.

Various classical flows were re-examined including, for example, vortex fusion, vortex reconnection, turbulence in Couette flows, swirling jet instability, and centrifugal instability. The subject of vortex dynamics was also presented in more complex situations than those generally considered. For example, wakes with temperature effects in the context of aeronautics; vortex instabilities in the presence of stratification, vortex shedding with stratification, and internal waves in the field geophysics; and finally turbulent structures, vortex burst, and vortex shedding behind obstacles in pure hydrodynamics. From an experimental viewpoint, PIV studies clearly showed their power in describing these complex flow situations.

The conference program can be downloaded at

www.lmm.jussieu.fr/MEMBRES/ROSSI/EUROMECH-SITE/program.html

The conference has shown that the "vortex" community is a vibrant one in Europe. Many works are presently under investigation in the field of vortex dynamics.

EUROMECH Colloquium 449

"Computational AeroAcoustics: from acoustic source modeling to farfield radiated noise prediction"

9-12 December 2003, Majestic Congress Center in Chamonix, France
Chairpersons: Eric Manoha and Pierre Sagaut

Topic

Computational AeroAcoustics (CAA) is known to be of exponentially growing interest, in both automotive and aeronautical industries. The numerical prediction of aerodynamic noise is of great interest for both academic and applied research. The noise generation mechanisms are not understood in many cases, and the diffraction/refraction of acoustic waves by turbulent flows is very difficult to predict. CAA is used nowadays as a tool to investigate and understand aerodynamic noise, and also for noise reduction via active control and unsteady shape optimisation.

Attendance

The colloquium gathered together 79 participants, most of them coming from Europe (11 countries, 74 participants) but also from beyond: USA (4 participants), Korea (1 participant) and Australia (2 participants). All major European research teams involved in CAA were present. Amongst them :

<u>Universities</u> (36 participants): École Centrale de Lyon (France), University of Southampton (United-Kingdom), Universities of Uppsala and KTH (Sweden), Technical University of Delft (Netherlands), University of Aachen (Germany), Trinity College of Dublin (Ireland).

<u>Research centers</u> (18 participants): NASA Langley (USA), ONERA (France), FOI (Sweden), DLR (Germany).

<u>Industries</u> (25 participants): Boeing Commercial Airplanes (USA), EADS and Airbus-Germany (Germany), Airbus-France (France), Volvo Car Corporation (Sweden). It should be noted that several CFD/CAA software editors, who are increasingly present in scientific conferences, also attended the colloquium: CD Adapco Group (United-Kingdom), EXA Europe (France) and Fluent Inc. (USA).

Technical programme

The Colloquium programme was based upon 3 "Invited Lectures" (NASA Langley, University of Southampton, German Aerospace Center) and 37 oral presentations in 8 Technical Sessions.

<u>Session 1: Advanced hybrid methods development</u>: Advanced hybrid methods typically associate (i) a local unsteady flow simulation of the Navier-

Stokes equations using CFD computation and (ii) a simulation of the acoustic propagation through a non-uniform mean flow using the linearized (or not) perturbation formulation of the Euler equations.

Session 2: Computation AeroAcoustic methods based on RANS: These methods include (i) stability analysis and (ii) turbulence reconstruction based on a stochastic model and source term modelling for the perturbation formulation of the Euler equations.

Session 3: Numerical methods development: These methods aim at developing advanced spatial, low-dispersion, low dissipation, high order (4th or 6th) schemes for the simulation of sound wave propagation through non-uniform flows using the Euler perturbation equations on structured and unstructured grids.

Session 4: Jet noise: Several approaches for jet noise prediction were presented, including the influence of temperature and complex geometries (serrated nozzles). These simulations are based on DNS for moderate Reynolds numbers (~ 2500) or LES for realistic flow (Re ~ 10^6). These unsteady computations are coupled to an acoustic integral method for the farfield noise prediction (Ffowcs Williams-Hawkings or Kirchhoff).

Session 5: Unstructured grids: Unstructured grids are of high interest when very complex geometries are considered. However, such grids are particularly adapted to 2nd order spatial schemes used for CFD. For CAA applications, the difficulty is to develop high order schemes with the same accuracy as provided by finite difference schemes on structured grids. Applications presented in this session address the use of Euler equations and discontinuous Galerkin equations to evaluate the accuracy of acoustic pulse advection.

Session 6: Airframe Noise: Airframe noise studies concern the numerical prediction of the aerodynamic noise radiated by a simple airfoil or a high lift wing with flap and slat. The methods are mostly zonal or hybrid: noise sources are simulated by use of the unsteady Navier-Stokes equations, then acoustic propagation through non-uniform mean flows uses the Euler equations, and finally integral equations are used for farfield noise predictions.

Session 7: Cavity noise: Cavity noise mechanisms are known to involve very strong physical interactions between aerodynamics and acoustics. Consequently, it represents a large application field of for CAA. Again, most CAA methods used for cavity noise prediction are hybrid methods, generally coupling LES or DNS for the near field and LEE (linearized Euler equations) for the mid and far fields.

Session 8: Internal noise: A typical internal noise problem is the fan noise propagating inside an engine nacelle and the radiation outside the duct.

Main results

This colloquium has offered the opportunity to share experiences dealing with the development and the use of numerical simulation for aeroacoustic studies. Emphasis has been put on modern developments relying on the coupling of CFD and CAA tools. The main topics addressed were the prediction of noise generation including several approaches recently developed (stochastic reconstruction, direct simulation, large-eddy simulation, non-linear disturbance equations, linear stability analysis), and the simulation of acoustic wave propagation, including direct simulation, linearized Euler equations and wall acoustic treatment modelling. Acoustic far-field prediction using integral methods (Kirchhoff integration, Lighthill-like and Ffowcs Williams-Hawkings models) were also addressed to a large extent.

All presented works were original. The most promising techniques are probably the hybrid methods in which several techniques are associated, each solving one particular mechanism in a specific region by use of the most appropriate set of equations. With the rapid increase in computing capacity (teraflop) and the development of coupling techniques between very different numerical methods, there is no doubt that CAA will soon become an industrial tool as widely used as CFD in the design of future vehicle projects.

Conclusions

The general quality of the audience and of the presented research suggest that a colloquium with similar topics should be organized again within 2 or 3 years, with the main challenge - acknowledged by all participants - being the accurate prediction of turbulent flow noise sources. In the meanwhile, industrial partners will be more and more involved in the development and applications of CAA tools, with the consequence that they probably will be better represented in future conferences devoted to CAA.

EUROMECH Colloquium 457

"Non linear modes of vibrating systems"

7-9 June 2004, Fréjus, France
Chairperson: Claude-Henri Lamarque

Euromech Colloquium 457 was held at the Villa Clythia in Fréjus (France), from 7-9 June 2004. There were 51 participants from 16 countries, mostly from Europe, but also from overseas (USA 3, Japan 2).

The main topic of the colloquium was Non Linear Modes of Vibrations, with many scientific questions being addressed. These range from theoretical issues, such as: definitions, methods for calculations, bifurcation analysis, interactions, and energy transfer, etc., through to applications of non linear modes: reduced-order modelling, experimental identification, non linear dampers, analysis of experimental results, etc.

The scientific lectures and discussions were organized according to the following four headings:

- Non linear modes, and methods for the construction of non linear modes
- Applications of non linear modes
- Reduced-order modelling
- Applications and related topics.

There were 44 oral presentations (20min), and among them five invited lectures (25min) given by L. Manevitch, A. H. Nayfeh , C. Pierre, H. Troger and A. Vakakis.

Scientific Résumé
Several remarks can be made under these headings:

Non linear modes andmethod for construction of non linear modes:
- analytical methods and calculations are limited to systems with a few degrees of freedom,
- mixed methods with numerical calculations have been presented, but require further development,
- superposition of modes is impossible in general, for theoretical reasons, and does not seem to be useful for general classes of non linear systems,
- applications of non linear modes are of the highest interest especially for analysing the phenomenon of energy pumping and for the design of non linear absorbers.

Reduced order modelling, applications and related topics:
-inertial manifold techniques provide an interesting frame for reduced order modelling, especially when assumptions regarding center manifold reduction cannot be verified,
-POD techniques are being extended to non linear frameworks providing interesting possibilities for order reduction.

In the spirit of Euromech Colloquia, lively discussions were organized between lectures, at the end of sessions and at the closure of the colloquium.
Others fruitful conclusions of this Euromech Colloquium 457 are the following:
-It was the first international conference focusing on this topic; many scientific works are in progress and another conference within 2 or 3 years should be organized, probably in Greece by Professor A. Vakakis with the help of some participants of the Euromech 457 Colloquium.
-A few sub-topics should be emphasized in this next conference: for example, energy pumping and localization phenomenon.
-Mathematicians and scientists in the field of fluid mechanics should be invited.

Participants, proceedings, support
Among the 51 participants, there were about 20 young scientists. Six Euromech grants of 200 Euro have been given to F. Dohnal (Austria), T. Inoue (Japan), Z. Hossain (Japan), P. Ribeiro (Portugal), C. Touzé (France), C. Souissi (Tunisia) according to the Euromech committee recommendations.
All the lecturers have been invited to submit a four page extended abstract, and the book of proceedings was given to all participants at the beginning of the Colloquium.
The financial support by ENTPE, CNRS, ENSTA, and Université de Provence is gratefully acknowledged.

EUROMECH Colloquium 458

"Advanced Methods in Validation and Identification of Nonlinear Constitutive Equations in Solid Mechanics"

21-23 September 2004, Institute of Mechanics of Lomonosov Moscow State University, Russia
Chairperson: Prof. R. A. Vasin

The EUROMECH Colloquium 458 was held at the Institute of Mechanics of Lomonosov Moscow State University (Russia) on 21-23 September, 2004. This colloquium was held during the period of the 250th anniversary celebration of MSU. There were 46 participants (including the students of MSU) from 8 countries. They presented 44 scientific reports (28 oral presentations and 16 posters). The aim of the conference was to provide opportunities for scientists to meet each other and to discuss their current research and modern conceptions in the field of the identification of constitutive equations in nonlinear mechanics of solids.

The colloquium covered new theoretical, experimental and numerical investigations of the mechanical behaviour of materials (including materials with complex microstructure). A number of important modern problems dealing with verification of the constitutive equations, organization of experiments, connections between microstructure and mechanical properties were discussed.

The scientific programme focused on:

- The problems of verification of constitutive equations
- Development of constitutive equations, including materials with complex structure
- Methods of identification of constitutive equations
- Role and schemes of virtual experiments
- Experimental observations and their explanation
- The problem of choosing the required model among the generous offerings in modern FEM software.

The scientific program was organised to promote a complex approach to the consideration of the problems mentioned above. The model representations were accompanied by identification procedures and experimental verification. Solutions of boundary value problems based on the presented models were compared with experimental data. Phenomenological approaches were combined with micro-structural information in the formulation and verification of constitutive equations discussed at the sessions. The schemes of virtual experiments and comparison of their results with real experimental

data were discussed. During the sessions, the results of several international research teams (French-Russian, German-Russian, French-Austrian etc.) were presented and discussed.

The time allowed for each oral presentation was 20 minutes; each session was concluded by discussion and exchange of ideas on the subject of the session. The talks were of a high scientific standard, and the informal atmosphere of the event, created by the Colloquium Organizing Committee, led to variety of discussions during the coffee breaks, the meals and the official dinner.
At the final session of the Colloquium, which was an open forum for all participants, the following conclusions were developed:
- The topics presented at the the Colloquium were urgent and discussions were very useful.
- As a result of discussions, the project of developing a standard for the mathematical model for a range of materials has been worked out.
- The Colloquium Organizing Committee proposes to recommend this standard to EUROMECH after concordance with the members of Colloquium Scientific Committee.

The papers, selected by Colloquium Scientific Committee on the basis of the talks, have been recommended for publication in Journal de Physique IV.

EUROMECH Colloquium 460

"Numerical Modelling of Concrete Cracking"

February 21-23 2005, University of Innsbruck, Austria
Chairperson: Prof. Günter Hofstetter

The reliable numerical simulation of the development of cracks in concrete plays an important role for the integrity assessment of concrete structures. To this end a large number of material models for concrete cracking based on different theories (e.g., damage mechanics, fracture mechanics, plasticity theory and combinations of these theories) as well as advanced finite element methods suitable for the representation of cracks have been developed in recent years. The aim of the Colloquium was to review and to assess available models for the numerical simulation of concrete cracking and to discuss new approaches. Special emphasis was put on the advantages and drawbacks of the different approaches for practical applications in Civil Engineering.
The lectures covered a broad spectrum of topics relating to numerical modelling of concrete cracking:

- Modelling of concrete cracking on the micro- and meso-scale,
- Smeared crack models,
- Discrete crack models,
- Elements with embedded discontinuities,
- Extended Finite Element Method,
- Modelling of concrete cracking for cyclic/dynamic loading,
- Modelling of concrete cracking for coupled problems,
- Numerical simulation of concrete structures.

Models for concrete cracking on the micro- and meso-scale are a means for a better understanding of the fracture mechanisms and for a partial substitution of expensive experiments. Open questions are (i) can the macroscopic properties of concrete, required for the numerical simulation of concrete structures, be derived from models on the micro- and meso-scale and (ii) can phenomenological ingredients of numerical models for concrete cracking be eliminated by models on the micro- and meso-scale? Regarding continuum models for concrete cracking on the macro-scale, it is still a challenge to numerically simulate the structural behaviour if truly three-dimensional stress states, as encountered, for example, in large concrete dams, are involved. Models for concrete cracking, based on the strong discontinuity approach and formulated either within the framework of elements with embedded discontinuities or within the framework of the

extended finite element method, open new perspectives on crack modelling by combining the advantages of the discrete and the smeared crack models. However, they also pose new problems to be solved, especially for the three-dimensional case. Further research endeavours, including both experimental and numerical investigations, are also required for dynamic loadings with high strain rates; the latter are encountered, e.g., due to rockfall or due to detonations. A promising research field is that of coupled problems. These offer great potential for the enhancement of numerical models for concrete cracking by accounting for the interaction between different phenomena, such as cracking induced, say, by changes in moisture content, by chemical reactions, by heat due to fire, etc. In this context, the wheel comes full circle by developing coupled models on the micro- and meso-scale in order to study the mutual interaction of different physical and chemical phenomena on the material behaviour. The final goal in Civil Engineering, namely the safety assessment of concrete structures by means of the numerical prediction of the structural behaviour until failure, was dealt with in the closing session of the colloquium.

EUROMECH Colloquium 464

"Fibre-reinforced solids: constitutive laws and instabilities"

28 September - 1 October 2004, La Residencia, Castro Urdiales, Spain
Chairperson: Ray W. Ogden

The Colloquium was held from 28 September to 1 October, 2004, at La Residencia, Castro Urdiales, Cantabria, Spain, in an excellent seaside location in a recently re-furbished building with state-of-the-art conference facilities. There were 34 participants from 10 countries (UK 7; Spain 7; USA 6; France 5; Germany 2; Austria 2; Italy 2; China 1; Israel 1; Sweden 1). There were 26 lecture presentations, each of 35 minutes duration, in the course of 10 sessions; there were no designated keynote lectures. The quality of the participants was very high and the presentations were generally excellent, covering a wide range of topics within the general theme of the Colloquium. The contributions included fundamental theoretical work on constitutive modelling, with particular reference to material symmetry considerations for materials subject to large deformations, alongside more applied topics and experimental results. Of particular interest was the topic of kink band formation, development, stability and failure, on which several talks were focused. The types of fibre-reinforced materials considered ranged from glass-fibre composites to biological tissues, in which the key component is the collagen fibre distribution. Several talks were devoted to biomechanical applications. In addition to elastic behaviour there was some discussion of viscoelastic and plastic effects in fibre-reinforced solids. It is clear that there is considerable scope for further development of constitutive laws for fibre-reinforced solids that are capable of large deformations and analysis of stabilities in such materials. This requires a more comprehensive body of experimental data than is currently available so that the models developed can be validated for a range of problems, geometries and loading conditions.

Euromech funding was used to support the following students: F. Kassianidis (UK), H. Le Quang (France), O. Lopez Pamies (France), E. Pena (Spain), A. Peres del Palomar (Spain).

The Colloquium was very successful, both from the scientific and social perspectives, and many participants commented favourably on the scientific content, the organization, the location and the conviviality of the occasion.

Objectives of the EUROMECH Mechanics Society

The Society is an international, non-governmental, non-profit, scientific organisation, founded in 1993. The objective of the Society is to engage in all activities intended to promote in Europe the development of mechanics as a branch of science and engineering. Mechanics deals with motion, flow and deformation of matter, be it fluid or solid, under the action of applied forces, and with any associated phenomena. The Society is governed by a Council composed of elected and co-opted members.

Activities within the field of mechanics range from fundamental research on the behaviour of fluids and solids to applied research in engineering. The approaches used comprise theoretical, analytical, computational and experimental methods. The Society shall be guided by the tradition of free international scientific co-operation developed in EUROMECH Colloquia.

In particular, the Society will pursue this objective through

- The organisation of European meetings on subjects within the entire field of mechanics.
- The establishment of links between persons and organisations including industry engaged in scientific work in mechanics and in related sciences.
- The gathering and dissemination of information on all matters related to mechanics.
- The development of standards for education in mechanics and in related sciences throughout Europe.

These activities which transcend national boundaries are to complement national activities.

The Society welcomes to membership all those who are interested in the advancement and diffusion of mechanics. It also bestows honorary membership, prizes and awards to recognise scientists who have made exceptionally important and distinguished contributions. Members may take advantage of benefits such as reduced registration fees to our meetings, reduced subscription to the European Journal of Mechanics, information on meetings, job vacancies and other matters in mechanics. Less tangibly but perhaps even more importantly, membership provides an opportunity for professional identification; it also helps to shape the future of our science in Europe and to make mechanics attractive to young people.