LAMINATED COMPOSITE PLATES

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The use of composites in all products - from sporting goods to bridges to satellites - is increasing. Composite materials consist of two or more materials combined in such a way that the individual materials are easily distinguishable. A common example of a composite is concrete. It consists of a binder (cement) and a reinforcement (gravel). Adding another reinforcement (rebar) transforms concrete into a three-phase composite.

The individual materials that make up composites are called constituents. Most composites have two constituent materials: a binder or matrix, and a reinforcement. The reinforcement is usually much stronger and stiffer than the matrix, and gives the composite its good properties. The matrix holds the reinforcements in an orderly pattern. Because the reinforcements are usually discontinuous, the matrix also helps to transfer load among the reinforcements.

Reinforcements basically come in three forms: particulate, discontinuous fiber, and continuous fiber. A particle has roughly equal dimensions in all directions, though it does not have to be spherical. Gravel, micro balloons, and resin powder are examples of particulate reinforcements. Reinforcements become fibers when one dimension becomes long compared to others. Discontinuous reinforcements (chopped fibers, milled fibers, or whiskers) vary in length from a few millimeters to a few centimeters. Most fibers are only a few microns in diameter, so it does not take much length to make the transition from particle to fiber. With either particles or short fibers, the matrix must transfer the load at very short intervals. Thus, the composite properties cannot come close to the reinforcement properties. With continuous fibers, however, there are few if any breaks in the reinforcements. Composite properties are much higher, and continuous fibers are therefore used in most high performance components, be they aerospace structures or sporting goods.

Matrix materials are usually some type of plastic, and these composites are often called reinforced plastics. There are other types of matrices, such as metal or ceramic, but plastics are by far the mos common. Suffice it to say for now that the two most common plasti matrices are epoxy resins and polyester resins.

Composite materials are available as plies or lamina. A single ply consists of fibers oriented in a single direction (unidirectional) or in two directions (bidirectional; for example a woven fabric). There are othe forms, but these are the most important for this discussion.

Composite properties are best in the direction of the fibers Perpendicular, or transverse, to the fibers, the matrix properties dominate because load must be transferred by the matrix every fiber diameter Because most structures are not loaded in a single direction, even though one direction may dominate, it is necessary to orient fibers in multiple directions. This is accomplished by stacking multiple plies together. Such a stack is called a laminate.

The most efficient composites have most of their fibers oriente in the primary load direction, and just enough fibers oriented in the othe directions to carry secondary loads and hold the structure togethe Efficiency means both low weight and low cost.

This study is intended to outline the mechanics of fiber-reinforce laminated plates, leading to a computational scheme that relates the in plane strain and curvature of a laminate to the tractions and bendin moments imposed on it. Although this is a small part of the overall fiel of fiber-reinforced composites, or even of laminate theory, it is a important technique that should be understood by all composite engineers.

Also the constitutive relations for isotropic materials can b viewed in matrix form. It can be shown that the extension to transversel isotropic composite laminate is very straightforward. Since each ply in laminate may be oriented arbitrarily, the elastic properties of th individual laminate can be transformed to a common direction. Finally the individual ply stresses against the applied tractions and moments t develop matrix governing relations for the laminate as a whole can b balanced.

The calculations for laminate mechanics are best done b computer, and algorithms are outlined for elastic laminates, laminate exhibiting thermal expansion effects, and laminates exhibiting viscoelastic response.

EVALUATION CRITERIA FOR ENVIRONMENTAL POLICY INSTRUMENTS

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This chapter sets out the range of costs and benefits which may be relevantin evaluating environmental policy instruments.

A central issue in evaluating the effects of environmental market mechanisms is their environmental impact. Environmental effectiveness is a key issue in evaluating all environmental policy measures.

The administration and compliance costs of market-based and regulatory environmental policy instruments will be an important consideration in evaluating the relative merits of different policy approaches.

Some environmental market mechanisms, including user charges, environmental taxes, and certain types of tradable permits, may generate government revenue.

Wider economic effects is the range of economic costs and benefits associated with different environmental instruments apart from the direct abatement costs, administration and compliance costs, and the costs of charges in tax revenues.

Soft effects of economic instruments are various possible effects of such instruments working through changes in attitudes and awareness.

Economic instruments are likely to be more effective at stimulating innovation in pollution-abatement technologies than regulations which merely require a given level of compliance.

The limitations which are placed on the scope of evaluation studies by resources and the availability of information need to be borne in mind in interpreting the results. A decision has to be made in any evaluation study concerning the timescale over which the effects of different policies are to be assessed.