An energy-absorbing block is described for use as (or in conjunction with) bumpers and similar objects used to receive and dissipate large amounts of impact energy. The block includes an inner core at least partially formed of elastomeric materials, such as rubber from discarded vehicle tires, with the core being at least substantially surrounded by an outer shell which is preferably at least partially formed of a rigid thermoplastic material. The block may also contain a reinforcing layer of material, such as glass fiber or fabric, positioned between the core and the shell or interspersed within the shell. The block may be mounted to a bumper such as a guardrail, and/or to a mounting structure such as a guardrail post or loading dock, via a fastener inserted through a mounting bore in the block.
BLOCKS FOR ABSORPTION OF COLLISION ENERGY

CROSS-REFERENCE TO RELATED APPLICATIONS


STATEMENT REGARDING FEDERALLY-FUNDED RESEARCH

[0002] This invention was made with United States government support awarded by the following agencies:

[0003] DOE (Dept. of Energy) Grant No. DE-FC26-00FT40598

[0004] The United States has certain rights in this invention.

FIELD OF THE INVENTION

[0005] The invention is directed to articles for absorbing impact energy, such as offset blocks for mounting between guardrails and guardrail posts; bumpers for use at truck loading docks and marine docks; and other articles which may or will encounter impacts by massive objects, and which should beneficially absorb large amounts of kinetic energy.

BACKGROUND OF THE INVENTION

[0006] Guardrails are commonly installed alongside United States highways in areas where it is desirable to prevent vehicles from leaving the highway, e.g., at elevated portions of highway or between opposing lanes of traffic. Such guardrails can be generally classified into one of two performance categories, rigid and non-rigid. Rigid guardrails are not intended to deflect upon impact, and are instead intended to constrain the vehicle and redirect it onto the roadway. As an example, trapezoidal concrete slabs are commonly used to provide rigid guardrails between adjacent lanes of traffic. Non-rigid guardrails, such as the standard steel w-beam, are intended to deflect upon impact so as to absorb and dissipate kinetic energy from an oncoming vehicle without overly damaging the vehicle and harming its passengers. The w-beam primarily dissipates impact energy via several mechanisms: plastic flexural deformation of the rail; deformation and breakage of support posts; and the “plowing” of support posts through the ground. It is estimated that 600-800 million feet of w-beam guardrail are currently installed in the United States.

[0007] There has been interest in improving the impact-absorbing qualities of guardrails (e.g. steel w-beams), as well as other types of barriers and railings. For instance, U.S. Pat. No. 6,149,134 and the patents cited therein describe composite and other guardrails which may be used as substitutes for common steel w-beam guardrails. However, there has thus far been little attention paid to the properties of the structures used to mount/anchor guardrails and other impact-dissipating structures, and the possibility of modifying their properties to achieve beneficial increases in their ability to dissipate energy.

SUMMARY OF THE INVENTION

[0008] The invention, which is defined by the claims set forth at the end of this document, is directed to bumpers and similar objects which are used to receive and dissipate large amounts of impact energy, and offset blocks and mounting posts for such objects. A basic understanding of some of the preferred features of the invention can be attained from a review of the following brief summary of the invention, with more details being provided elsewhere in this document.

[0009] A basic exemplary version of the present invention provides an offset block for the absorption of impact energy, wherein the block includes an inner core which is at least partially formed of elastic material, and an outer shell which is at least partially formed of a rigid material. The core of the block is preferably made from recycled elastomeric materials such as rubber from discarded vehicle tires. The core also preferably has an outer surface configured to promote adequate adhesion to the shell. For instance, the core surface may contain one or more elongated grooves depressed inwardly into the length of the surface of the core. Alternatively or additionally, the core surface may be lightly ground to leave a rough finish to promote the desired adhesion between the shell and the core.

[0010] The core of the block is substantially surrounded by the rigid outer shell. The elastic material of the core provides the compressive strength necessary to absorb impact forces. However, without a rigid shell, the core is vulnerable to excessive buckling upon impact. Therefore, the rigid material of the shell is bonded to the elastic core so as to provide the protection necessary to prevent excessive damage to the core. The shell is preferably at least partially made from recycled materials such as polycarbonate, acrylonitrile butadiene styrene (ABS), and polypropylene. In combination, the rigid shell and elastic core absorb energy from impact forces and distribute such energy evenly across the surface of the block. This helps to provide a uniformly smooth collapse of the block under impact.

[0011] Additionally, the rigid shell helps to improve the life and performance of the block, allowing the core to absorb multiple impacts before needing replacement. Further, the rigid shell provides improved resistance to freezing temperatures, improved moisture stability, and/or an improved resistance to drastic changes in temperature. Thus, the rigid shell helps to prevent deterioration of the block from exposure to environmental conditions.

[0012] The rigid shell can usefully contain a fibrous reinforcing material embedded therein, such as single, bundled or braided continuous fibers, discontinuous fibers, or woven or non-woven fabrics. A particularly preferred reinforcing material includes glass fibers. Alternatively or additionally, a layer of fibrous reinforcing material may be interposed between the shell and the core of the block. In a preferred version, chopped and/or continuous glass fibers are used for reinforcement.

[0013] The block may be installed in different settings for applications requiring shock absorption. The block preferably includes a mounting bore which extends through the block, thereby allowing a fastener to be inserted to engage the block to a bumper (such as a guardrail) and/or a mounting structure (such as a mounting post for a guardrail). For instance, the block may be mounted on a bumper to
enhance its ability to dissipate impact energy, and/or to better protect the bumper from damage upon impact. The block may also be mounted on a mounting structure that is immovably anchored to its surroundings, such as a guardrail or loading dock. In addition, two or more energy absorbing blocks may be used in combination with each other to provide additional protection from impact forces. For instance, multiple blocks may be stacked together and mounted on a bumper, mounted on a mounting structure, interposed between a bumper and an anchored mounting structure (e.g. a sunken post), or positioned in any other desired configuration. Because the block is easily mounted to other blocks or to mounting structures, it can be used in a variety of configurations.

[0014] Further, the block is easy to replace. For instance, a damaged block mounted on a guardrail can be easily replaced with a substitute block without replacing the entire guardrail. By simply removing the fastener, the block can be removed from the mounting structure, reducing labor costs.

[0015] The description set out above is merely of exemplary preferred versions of the invention, and it is contemplated that numerous additions and modifications can be made. These examples should not be construed as describing the only possible versions of the invention, and the true scope of the invention will be defined more fully from the following detailed description and claims of the preferred version of the invention made in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIG. 1 shows a cross-section of the block 100 of the present invention, showing the inner core 102 surrounded by a rigid shell 104, where the core 102 may bear discontinuities (such as grooves 106) to assist in the bonding between the core 102 and shell 104, and the shell 104 (and/or the interface between the core 102 and shell 104) may contain reinforcing material 108 (e.g., fibrous reinforcements).

[0017] FIG. 2 shows an exploded view of a pair of the blocks 100 as they would be provided in between an anchored mounting structure 114 (e.g. a sunken post) and a guardrail 116.

DETAILED DESCRIPTION OF PREFERRED VERSIONS OF THE INVENTION

[0018] FIG. 1 shows an energy-absorbing block 100 having an elastomeric inner core 102 substantially surrounded by an outer shell 104. The core 102 is preferably made at least partially of recycled elastomeric materials, such as rubber from discarded tires. The outer shell 104 is preferably made at least partially made of recycled thermoplastic materials, such as polymers from household waste, discarded computer electronic housings, or other sources. The block 100 also preferably includes a reinforcing layer 108 of fibrous materials, e.g., individual or cabled strands, and/or woven or nonwoven fabrics. The reinforcing layer 108 may separate the inner core 102 from the outer shell 104, or it may be interspersed within the outer shell 104 when it is molded.

[0019] In a preferred version, the block 100 is made by compression molding recycled thermoplastic pellets about the core 102 to form a rigid outer shell 104. While compression molding is a preferred method for forming the outer shell 104 about the core 102, other molding techniques (e.g., injection molding) could be used instead. While thermoplastics are preferred owing to their cost and ease of use, it is also possible that thermostets might be used for the outer shell 104. Testing has revealed that without the outer shell 104, the elastomeric core 102 is vulnerable to excessive damage at the immediate point of impact, and it will rapidly lose elasticity. By adding the outer shell 104, impact forces are distributed more evenly across the area of the block 100, increasing the energy dissipation performance and lifetime of the block 100.

[0020] The inner core 102 is preferably prepared by using a saw or other cutting tool to cut discarded vehicle tires into the desired shape and size. The size and shape of the core pieces can vary as the user desires. It is notable that recycled tires are useful materials for the core 102 not only owing to their cost and availability, but also because the treads, grooves and other discontinuities in their surfaces readily allow the shell 104 to complementarily flow about and bond with the core 102 during molding. However, while the elastic inner core 102 is preferably made of portions of discarded tires, other or additional elastomeric materials may be used. If other sources of elastomeric materials are used, the surface of the core 102 may need to be altered, such as by adding grooves 106 or other discontinuities to provide the desired surface for molding. A simple option is to simply sand or otherwise scuff the surface of the core 102 to present a roughened surface for molding.

[0021] The thermoplastic used for the shell 104 is preferably at least 90% pure for superior compression, tension and bending properties, though other purity levels may be acceptable if properties are not unduly degraded. Recycled 90% pure ABS pellets have proven to result in a durable shell 104 which retains at least 70% of its tensile, bending and compressive strength after 18 months of aging under harsh conditions (approximately equal to 60 years of standard environmental use).

[0022] Once the piece(s) of the core 102 are configured as desired, the core 102 may be placed in a compression or other mold having the desired shape, and the shell 104 may be molded about the core 102. While the mold could present virtually any shape for the exterior of the shell 104, it is preferable that the mold define the shell 104 with an outer surface evenly spaced from, and complementarily shaped with respect to, the core 102 (i.e., that the shell 104 be defined with generally uniform thickness about the core 102). If a reinforcing layer 108 is desired between the core 102 and the shell 104 to further protect the core 102 and distribute loads, the core 102 may be wrapped with fabric or reinforcing strands. A preferred material for the reinforcing layer 108 is glass fiber or cloth, but fiber or cloth of other materials, such as carbon, aramid (KEVLAR), metal, etc. can be used. Alternatively or additionally, rather than situating the reinforcing layer 108 as a boundary between the core 102 and shell 104, it may be embedded in the shell 104, as by interspersing the fibrous reinforcing material among the pellets of the outer shell 104 (e.g., as chopped strands).

[0023] The shell 104 is preferably molded about the core 102 by simply pouring thermoplastic particles (beads/pellets, powder, or flakes) into the lower section of a compression mold, inserting the core 102 therein, and then further
filling the mold with additional particles prior to closing it with the upper section of the mold. The mold sections are then forced together under heat to compression mold the shell 104 about the core 102. In tests, a SO-230H compression molding machine (PHI-Tulip Corp., City of Industry, Calif.) with a maximum force of 5 tons was used. The two top and bottom pressure plates, used to close the mold sections and apply pressure thereon, are first wrapped with aluminum foil or a similar material for easy cleaning after molding. As the polymer melts about the core 102, they flow about the core 102 (and any reinforcing layer 108), and fill the voids, grooves, and other discontinuities of the inner core 102 to form a complementary interlock between the shell 102 and core 104.

[0024] When molding is complete, the pressure is released and the mold is removed from the machine for cooling. Forced air or liquid cooling may be used to speed the cooling process if desired. When cool, the mold sections are removed from the molded block 100, and any finishing modifications (such as a mounting bore 110) may be added. Such a mounting bore 110 could be formed by simply drilling a hole through the block 100, and a liner (such as a length of pipe/tubing) could be fit therein if desired. Alternatively, a mounting bore 110 might be formed upon initial molding of the block 100: the mold sections could include a protrusion which defines a bore 110, and the thermoplastic beads (or other matter to be molded into the shell 104) and tire sections (or other material defining the core 102) can be fit about the protrusion such that when the compression molding of the block 100 is complete, the mounting bore 110 is defined in the block 100.

[0025] Once prepared, the block 100 of the present invention is ready for use in settings where it will be subjected to impact forces. As an example, in FIG. 2 (where the block of FIG. 1 is shown along the lines 1–1), one or more of the blocks 100 may be used in a guardrail system 118 where the block(s) 100 are mounted to an anchored mounting structure 114, such as a wooden post sunk into the ground (as depicted in FIG. 2), the side of a pier or loading dock, or some other structure that might be subjected to impact from vehicles, cargo, or other objects. The block(s) 100, which may be stacked to provide the desired thickness, may be mounted to the mounting structure 114 via a fastener 112 inserted through the mounting bore(s) 110 of the block(s) 100. If desired, the block(s) 100 can be interposed between the anchored mounting structure 114 and a bumper structure 116, e.g., a guardrail, so as to enhance the ability of the bumper structure 116 to dissipate impact energy. Since the blocks are relatively inexpensive, they may be replaced once they become unduly worn, and they are also suitable for temporary and high-wear usage, e.g., as disposable parking/landing skids for vehicles and cargo. Their durability and environmental resistance also makes them suitable for use in underwater and/or corrosive environments, for example, as bumpers or skids installed on boats, docks/piers, boat ramps, and the like.

[0026] The invention is not intended to be limited to the preferred versions described above, but rather is intended to be limited only by the claims set out below. Thus, the invention encompasses all different versions that fall literally or equivalently within the scope of these claims.

What is claimed is:
1. A block for absorption of impact energy comprising:
   a) an inner core made at least partially of an elastic material; and
   b) an outer shell made of a rigid material, the shell at least substantially enclosing the core.
2. The block of claim 1 wherein the core has an outer surface including at least one elongated groove depressed inwardly into the surface.
3. The block of claim 2 wherein the elongated groove extends along the entire length of the outer surface of the core.
4. The block of claim 1 wherein the shell is at least partially formed of thermoplastic material.
5. The block of claim 1 wherein the core is at least partially formed of tire material.
6. The block of claim 1 wherein the shell has a fibrous reinforcing material embedded therein.
7. The block of claim 6 wherein the reinforcing material is cloth.
8. The block of claim 6 wherein the reinforcing fiber is individual strands of material.
9. The block of claim 1 wherein a layer of a fibrous reinforcing material is interposed between the outer shell and the inner core.
10. The block of claim 9 wherein the reinforcing material is cloth.
11. The block of claim 1 in combination with a bumper on which the block is mounted.
12. The block of claim 1 in combination with a mounting structure on which the block is mounted, the mounting structure being immovably anchored to its surroundings.
13. The block of claim 1, in combination with a bumper and an immovable mounting structure, the block being interposed between the bumper and mounting structure.
14. Two or more of the blocks of claim 1, the blocks being adjacent affixed together.
15. The blocks of claim 14, wherein the two or more blocks are interposed between a bumper and an immovable mounting structure.
16. A block for absorption of impact energy, the block being situated on an immovable mounting structure, the block comprising:
   a) an elastic inner core;
   b) a rigid shell about the core, the shell including opposing side walls, opposing top and bottom walls extending between the side walls, and opposing front and rear faces having the side walls and top and bottom walls extending therebetween; and
   c) at least one mounting bore extending through the front face to the rear face through which a fastener may be inserted to engage the block to the mounting structure.
17. The block of claim 16 wherein the shell is made at least partially from thermoplastic material.
18. The block of claim 16 wherein the shell substantially covers the inner core.
19. The block of claim 16 further comprising a reinforcing material embedded within the shell.
20. A block for absorption of impact energy, the block being situated on a bumper, the block comprising:
a) an at least partially elastic core;
b) a shell of rigid material at least substantially enclosing the core;
c) a reinforcing material interposed between the core and the shell; and
d) a mounting bore extending through the bumper through which a fastener may be inserted to engage the block to the bumper.

21. The block of claim 20, wherein the core is made from recycled elastomeric materials.
22. The block of claim 20, wherein the reinforcing material includes at least partially continuous fibers.
23. The block of claim 20, wherein the shell is made at least partially from recycled thermoplastic material.