

# Environmental, Health, and Safety Guidelines for Toll Roads

## Introduction

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP)<sup>1</sup>. When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. These industry sector EHS guidelines are designed to be used together with the **General EHS Guidelines** document, which provides guidance to users on common EHS issues potentially applicable to all industry sectors. For complex projects, use of multiple industry-sector guidelines may be necessary. A complete list of industry-sector guidelines can be found at:

[www.ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines](http://www.ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines)

The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new projects / facilities by existing technology at reasonable costs. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets, with an appropriate timetable for achieving them. The applicability of the EHS Guidelines should be tailored to the hazards and risks established for each project on the basis of the results of an environmental assessment in which site-specific variables, such as host country context, assimilative capacity of the environment,

<sup>1</sup> Defined as the exercise of professional skill, diligence, prudence and foresight that would be reasonably expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally. The circumstances that skilled and experienced professionals may find when evaluating the range of pollution prevention and control techniques available to a project may include, but are not limited to, varying levels of environmental degradation and environmental assimilative capacity as well as varying levels of financial and technical feasibility.

and other project factors, are taken into account. The applicability of specific technical recommendations should be based on the professional opinion of qualified and experienced persons. When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures than those provided in these EHS Guidelines are appropriate, in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

## Applicability

The EHS Guidelines for Toll Roads include information relevant to construction, operation and maintenance of large, sealed road projects including associated bridges and overpasses.<sup>2</sup> Issues associated with the construction and operation of maintenance facilities are addressed in the **General EHS Guidelines**. Issues associated with sourcing of construction materials are presented in the EHS Guidelines for Construction Materials Extraction, while those related to vehicle service areas are included in the EHS Guidelines for Retail Petroleum. This document is organized according to the following sections:

- Section 1.0 — Industry-Specific Impacts and Management
- Section 2.0 — Performance Indicators and Monitoring
- Section 3.0 — References and Additional Sources
- Annex A — General Description of Industry Activities

<sup>2</sup> Elements of this Guideline document apply to smaller scale and / or unsealed road projects.

## 1.0 Industry-Specific Impacts and Management

The following section provides a summary of EHS issues associated with road projects, which occur during the construction and operation phase, along with recommendations for their management. Recommendations for the management of EHS issues during the decommissioning phase are provided in the **General EHS Guidelines**.

### 1.1 Environment

Environmental issues during the construction and operation of roads are similar to those of other large infrastructure projects involving significant earth moving and civil works and their prevention and control recommendations are presented in the **General EHS Guidelines**. These impacts include, among others, construction site waste generation; soil erosion and sediment control from materials sourcing areas and site preparation activities; fugitive dust and other emissions (e.g. from vehicle traffic, land clearing and movement, and materials stockpiles); noise from heavy equipment and truck traffic; and potential hazardous materials and oil spills associated with heavy equipment operation and fuelling activities.

Environmental issues specific to construction and operation of roads include the following:

- Habitat alteration and fragmentation
- Stormwater
- Waste
- Noise
- Air emissions
- Wastewater

### Habitat Alteration and Fragmentation

Disruption of terrestrial and aquatic habitats can occur both during construction of a road and during maintenance of the right-of-way.

#### *Road Construction*

Construction activities along a road alignment may adversely affect wildlife habitats, depending on the characteristics of existing vegetation, topographic features, and waterways. Examples of habitat alteration from these activities include fragmentation of forested habitat; loss of nesting sites of listed rare, threatened, or endangered species and / or high biodiversity / sensitive habitat; disruption of watercourses; creation of barriers to wildlife movement; and visual and auditory disturbance due to the presence of machinery, construction workers, and associated equipment. In addition, sediment and erosion from construction activities and stormwater runoff may increase turbidity of surface waters.

Management practices to prevent and control impacts to terrestrial and aquatic habitats include:

- Siting roads and support facilities to avoid critical terrestrial and aquatic habitat (e.g. old-growth forests, wetlands, and fish spawning habitat) utilizing existing transport corridors whenever possible;
- Design and construction of wildlife access to avoid or minimize habitat fragmentation, taking into account motorist safety and the behavior and prevalence of existing species. Possible techniques for terrestrial species may include wildlife underpasses, overpasses, bridge extensions, viaducts, enlarged culverts, and fencing. Possible techniques for aquatic species include bridges, fords, open-bottom or arch culverts, box and pipe culverts;<sup>3</sup>

<sup>3</sup> Additional information on the design of wildlife crossing and passage structures is available in "Chapter 3: Designing for Environmental Stewardship in

- Avoidance or modification of construction activities during the breeding season and other sensitive seasons or times of day to account for potentially negative effects;
- Preventing short and long term impacts to the quality of aquatic habitats by minimizing clearing and disruption of riparian vegetation; providing adequate protection against scour and erosion; and giving consideration to the onset of the rainy season with respect to construction schedules;<sup>4</sup>
- Minimizing removal of native plant species, and replanting of native plant species in disturbed areas;
- Exploring opportunities for habitat enhancement through such practices as the placement of nesting boxes in rights-of-way, bat boxes underneath bridges, and reduced mowing to conserve or restore native species;<sup>5</sup>
- Management of construction site activities as described in relevant sections of the **General EHS Guidelines**.

### *Right-of-Way<sup>6</sup> Maintenance*

Regular maintenance of vegetation within road rights-of-way is necessary to avoid interference with vehicle travel and road maintenance. Unchecked growth of trees and plants can cover signals and signs, restrict motorist visibility, and fall onto the road and overhead power lines.

Regular maintenance of rights-of-way to control vegetation may involve the use of mechanical methods (e.g. mowing), manual methods (e.g. hand pruning), and the use of herbicides.

Vegetation maintenance beyond that which is necessary for

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Construction and Maintenance' of Environmental Stewardship Practices, Procedures, and Policies for Highway Construction and Maintenance, National Cooperative Highway Research Program (NCHRP) Project 25-25 (04) and Evink, G. (2002)

<sup>4</sup> Additional information on techniques for the protection of riparian and wetland areas is provided in Chapter 3 and Chapter 4, NCHRP Project 25-25 (04) and Nova Scotia Department of Transportation and Public Works Environmental Protection Plan (<http://www.gov.ns.ca/tran/enviroservices>)

<sup>5</sup> Examples of additional habitat restoration strategies are presented in Chapter 3 and Chapter 10, NCHRP Project 25-25 (04)

<sup>6</sup> Also known as a "wayleave" or "easement" in some countries, but referred to as right-of-way for the purposes of these Guidelines.

safety may, by removing unnecessary amounts of vegetation, result in the continual replacement of successional species and an increased likelihood of the establishment of invasive species.

Management practices to prevent, minimize, and control impacts from rights-of-way maintenance include:

- Implementation of integrated vegetation management (IVM).
  - From the edge of the road area to the boundary of the right-of-way, vegetation is structured with smaller plants near the road and larger trees further away to provide habitats for a wide variety of plants and animals<sup>7</sup>
  - Planting of native species and removal of invasive plant species<sup>8</sup>
  - Use of biological, mechanical, and thermal vegetation control measures where practical, and avoiding use of chemical herbicides

An integrated approach to vegetation management may indicate that use of herbicides is the preferred approach to control fast-growing vegetation within road rights-of-way. In this case, users (e.g. road owners or contractors) should take the following precautions:

- Training of personnel to apply herbicides and ensure that personnel have received applicable certifications or

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<sup>7</sup> Mowing can be used to control growth of ground covers, minimize propagation of plants in the track area, and prevent the establishment of trees and shrubs in rights-of-way. Herbicides, in combination with mowing, can control fast-growing weedy species that have a potential to mature to heights over those permitted within the right-of-way. Trimming and pruning can be utilized at the boundaries of rights-of-way to maintain corridor breadth and prevent the encroachment of tree branches. Hand removal or removal of vegetation, while labor intensive, can be used in the vicinity of structures, streams, fences, and other obstructions that make the use of machinery difficult or dangerous.

<sup>8</sup> Dense, thorny native shrubs can be used to help deter trespassers. Native plants can also help to stabilize soils, reducing erosion. Waste from removal of invasive species should be disposed of (e.g. by incineration or at a landfill) to avoid accidental spreading of the weeds to new sites. Invasive species should be removed during flowering periods to avoid dispersal of seeds.

equivalent training where such certifications are not required;<sup>9</sup>

- Compliance with international restrictions on pesticide use;<sup>10</sup>
- Restriction of herbicide use to those that are manufactured under license, and registered / approved by the appropriate authority and in accordance with the Food and Agriculture Organization's (FAO) International Code of Conduct on the Distribution and Use of Pesticides;<sup>11</sup>
- Use only of herbicides that are labeled in accordance with international standards and norms, such as the FAO Revised Guidelines for Good Labeling Practice for Pesticides;<sup>12</sup>
- Review of manufacturer's directions on maximum recommended dosage or treatment, as well as published reports on reduced rate of herbicide application without loss of effect,<sup>13</sup> and application of the minimum effective dose;
- Application of herbicides based on criteria (e.g. field observations, weather data, time of treatment, and dosage) and maintenance of a pesticide logbook to record such information;
- Selection of application technologies and practices designed to reduce unintentional drift or runoff;
- Maintenance and calibration of herbicide application equipment in accordance with manufacturer's recommendations;
- Establishment of untreated buffer zones or strips along water sources, rivers, streams, ponds, lakes, and ditches to help protect water resources;

- Contamination of soils, groundwater, or surface water resources, due to accidental spills during transfer, mixing, and storage of herbicides, should be prevented by following the hazardous materials storage and handling management practices in the **General EHS Guidelines**.

### Stormwater

Construction or widening of sealed roads increases the amount of impermeable surface area, which increases the rate of surface water runoff. High stormwater flow rates can lead to stream erosion and flooding. Stormwater may be contaminated with oil and grease, metals (e.g. lead, zinc, copper, cadmium, chromium, and nickel), particulate matter and other pollutants released by vehicles on the roadway, in addition to deicing salts (e.g. sodium chloride and magnesium chloride) and their substitutes (e.g. calcium magnesium acetate and potassium acetate) from road maintenance facilities in colder climates. Stormwater may also contain nutrients and herbicides used for management of vegetation in the rights-of-way.

In addition to the management practices for stormwater during construction and operations presented in the **General EHS Guidelines**, practices applicable to roadways include the following:<sup>14</sup>

#### *General Stormwater Management*

- Use of stormwater management practices that slow peak runoff flow, reduce sediment load, and increase infiltration, including vegetated swales (planted with salt-resistant vegetation); filter strips; terracing; check dams; detention ponds or basins; infiltration trenches; infiltration basins; and constructed wetlands;
- Where significant oil and grease is expected, using oil / water separators in the treatment activities;

<sup>9</sup> Examples of certification schemes are provided by the US EPA Certification of Pesticide Applicators (40 CFR 171), which categorizes pesticides as either "unclassified" or "restricted" and requires workers that apply unclassified pesticides to be trained according to the Worker Protection Standard (40 CFR Part 170) for Agricultural Pesticides. It further requires restricted pesticides to be applied by or in the presence of a certified pesticide applicator.

<sup>10</sup> Stockholm Convention on Persistent Organic Pollutants (2001).

<sup>11</sup> FAO (2002a)

<sup>12</sup> FAO (2002b)

<sup>13</sup> Danish Agricultural Advisory Service (DAAS) (2000)

- Regular inspection and maintenance of permanent erosion and runoff control features;

### *Road Paving*<sup>15</sup>

- Paving in dry weather to prevent runoff of asphalt or cement materials;
- Use of proper staging techniques to reduce the spillage of paving materials during the repair of potholes and worn pavement. This may include covering storm drain inlets and manholes during paving operations; using erosion and sediment control measures to decrease runoff from repair sites; and utilizing pollution prevention materials (e.g. drip pans and absorbent material on paving machines) to limit leaks and spills of paving materials and fluids;
- Reducing the amount of water used to control dust, and using sweeping practices rather than washing. Collecting and returning swept material to aggregate base or disposing as solid waste, as described in the **General EHS Guidelines**;
- Avoiding the generation of contaminated runoff from cleaning of asphalt equipment by substituting diesel with vegetable oil as a release and cleaning agent; containing cleaning products and contaminated asphalt residues; scraping before cleaning; and conducting cleaning activities away from surface water features or drainage structures.

### *Road Deicing*

Colder climates may require the clearing of snow and ice from road surfaces during winter months. Stormwater management recommendations in this context include:<sup>16</sup>

<sup>14</sup> The adoption of specific recommendations should be based on an identification of environmentally sensitive areas along the transport corridor.

<sup>15</sup> Additional recommendations on paving activities management are presented in "Chapter 5: Pavement Materials and Recycling" of NCHRP Project 25-25 (04)

<sup>16</sup> Additional recommendations on the management of road de-icing methods provided in "Source Water Protection Practices Bulletin: Managing Highway Deicing to Prevent Contamination of Drinking Water" USEPA 816-F-02-019

- Primary use of mechanical deicing methods (e.g. sweepers and plows) complemented by chemical means if necessary;
- Pre-treating of pavement surfaces with anti-icing methods prior to the onset of snow or ice to reduce the need for subsequent applications and allow for easy removal;
- Selectively applying anti-icing and deicing agents based on expected pavement temperatures and the use of road weather information systems;
- Training employees in the application of anti-icing and deicing agents at optimum rates and times, and routinely calibrating deicer application equipment;
- Selecting the type of anti-icing and deicing agents based on the location of environmentally sensitive areas and the potential impacts of the particular agent;<sup>17</sup>
- Designing roads and bridges to minimize the accumulation of drifting snow on the roadway;<sup>18</sup>
- Designing drainage and site reinstatement to minimize impacts of anti-icing and deicing agent runoff to surface water and vegetation.<sup>19</sup>

### **Waste**

Solid waste may be generated during construction and maintenance of roads and associated structures. Significant quantities of rock and soil materials may be generated from earth moving during construction activities. Solid waste generation during operation and maintenance activities may include road resurfacing waste (e.g. removal of the old road surface material);

(2002) and Chapter 8: Winter Operations and Salt, Sand, and Chemical Management of NCHRP Project 25-25 (04)

<sup>17</sup> Salts and acetates can create potentially negative consequences to soil and aquatic environments and should be carefully selected based on site specific circumstances, such as distance to receiving water bodies and the type of local aquatic habitat.

<sup>18</sup> Specific design recommendations applicable to roadway and bridge structures, the use of structural or living fences, and other methods are provided in numerous sources including "Chapter 3: Designing for Environmental Stewardship in Construction and Maintenance" of NCHRP Project 25-25 (04)

<sup>19</sup> Specific stormwater management design recommendations for roads are available in numerous sources including Chapter 3 of NCHRP Project 25-25 (04)

road litter, illegally dumped waste, or general solid waste from rest areas; animal carcasses; vegetation waste from right-of-way maintenance; and sediment and sludge from stormwater drainage system maintenance (including sediment traps and oil / water separation systems). Paint waste may also be generated from road and bridge maintenance (e.g. due to removal of old paint from road stripping and bridges prior to re-painting). Waste management strategies include:

### *Construction Phase*

- Management of construction site excavation materials according to the recommendations of the **EHS Guidelines for Construction Materials Extraction** and the **General EHS Guidelines**;

### *Road Resurfacing*

- Maximizing the rate of recycling of road resurfacing waste either in the aggregate (e.g. reclaimed asphalt pavement or reclaimed concrete material) or as a base;
- Incorporating recyclable materials (e.g. glass, scrap tires, certain types of slag and ashes) to reduce the volume and cost of new asphalt and concrete mixes.<sup>20</sup>

### *Miscellaneous Wastes*

- Collecting road litter or illegally dumped waste and managing it according to the recommendations in the **General EHS Guidelines**. Provision of bottle and can recycling and trash disposal receptacles at parking lots to avoid littering along the road;
- Manage herbicide and paint inventories to avoid having to dispose of large quantities of unused product. Obsolete

product should be managed as a hazardous waste as described in the **General EHS Guidelines**;

- Collecting animal carcasses in a timely manner and disposing through prompt burial or other environmentally safe methods;
- Composting of vegetation waste for reuse as a landscaping fertilizer;
- Managing sediment and sludge removed from storm drainage systems maintenance activities as a hazardous or non-hazardous waste (see **General EHS Guidelines**) based on an assessment of its characteristics.

### *Painting Activities*

- Management of all removed paint materials suspected or confirmed of containing lead as a hazardous waste;
- Use of a system to collect paint waste when removing old paint containing lead. For a simple scraping operation, ground-covering tarps may be sufficient. For a blasting operation, an enclosure with a negative pressure ventilation system may be necessary;
- Grinding of removed, old road surface material and re-use in paving, or stockpiling the reclaim for road bed or other uses. Old, removed asphalt may contain tar and polycyclic aromatic hydrocarbons and may require management as a hazardous waste.

### **Noise**

Traffic noise is generated by vehicle engines, emission of exhaust, aerodynamic sources, and tire / pavement interaction. For vehicle speeds over 90 kilometers per hour (km/h), the noise from the tire / pavement interaction predominates.<sup>21</sup> Traffic noise can be a significant nuisance and may be loud enough to

<sup>20</sup> Additional information on the reuse of reclaimed concrete or asphalt and the use of recyclable materials in the aggregate is provided in numerous sources including "Chapter 5: Pavement, Materials, and Recycling" of NCHRP Project 25-25 (04)

<sup>21</sup> The noise level is influenced by the type, volume, and speed of traffic (e.g. one five-axle truck sounds about as loud as 28 cars when traveling at 90 km/hr). US Department of Transportation, Federal Highway Administration. Highway Traffic Noise. <http://www.fhwa.dot.gov/environment/htnoise.htm>.

interfere with normal conversation<sup>22</sup> and can cause stress in children and raise blood pressure, heart rates, and levels of stress hormones.<sup>23</sup> Traffic noise levels are reduced by distance, terrain, vegetation, and natural and manmade obstacles.

Management practices to prevent, minimize, and control noise include:

- Consideration of noise impacts during road design to prevent adverse impacts at nearby properties through the placement of the road right-of-way and / or through the design and implementation of noise control measures discussed below.<sup>24, 25</sup>
- Design and implementation of noise control measures may include the following:
  - Construction of the road below the level of the surrounding land
  - Noise barriers along the border of the right-of way (e.g. earthen mounds, walls, and vegetation)<sup>26</sup>
  - Insulation of nearby building structures (typically consisting of window replacements)
  - Use of road surfaces that generate less pavement / tire noise such as stone-matrix asphalt<sup>27</sup>

<sup>22</sup> At a distance of 50 ft, traffic noise ranges from about 70 dBA for cars to 90 dBA for heavy trucks.

<sup>23</sup> Evans, Gary W. et al. (2001)

<sup>24</sup> For example, the U.S. Federal Highway administration has established noise impact criteria, such as  $L_{10}$  (sound level exceeded 10 percent of the time) = 70 dBA for residential land use. A new road project should not cause a significant increase in existing noise levels at nearby properties.

<sup>25</sup> Traffic noise is generally not perceived as a nuisance for people who live more than 150 meters from heavily traveled highways or more than 30 to 60 meters from lightly traveled roads.

<sup>26</sup> The most effective noise abatement measures include noise barriers and mounds, which can reduce noise by 5 dBA or more. The cost of noise walls in the US has been estimated at \$1.3 million per mile (NCHRP Project 25-25 (04))

<sup>27</sup> Stone-matrix asphalt (SMA) is one of several alternative surfaces that can be used in new roads or as surface treatment in existing roads to provide a quieter surface. A double-layered porous asphalt construction results in a further reduction of traffic noise, from 3 to 4 dBA at 50 km/h up to 5.5 dBA at 100 km/h compared with regular asphalt and 7 to 12 dBA quieter than concrete pavements (NSW Roads and Traffic Authority (RTA), 2005).

## Air Emissions

Air emissions are typically related to dust during construction and exhaust from vehicles. Management practices for air emissions include:

- Prevention and control of dust emissions during construction and maintenance activities as described in the **General EHS Guidelines**;
- Operation and maintenance of maintenance vehicle fleets according to the recommendations in the **General EHS Guidelines**;
- Consideration of design options for the reduction of traffic congestion, including:
  - Automated toll charging systems
  - Availability of high-occupancy vehicle lanes
  - Minimizing grade changes, at-grade crossings, and sharp curves which can promote congestion
  - Design of roadway to shed water, and prompt removal of snow to minimize rolling resistance, as well as to enhance safety
  - Maintenance of the road surface to preserve surface characteristics (e.g. texture and roughness)

## Wastewater

Wastewater discharges from maintenance facilities and from rest areas should be managed according to the recommendations provided in the **General EHS Guidelines**, and may include connection to centralized wastewater collection and treatment systems and / or use of properly designed and operated septic systems.

## 1.2 Occupational Health and Safety

Guidance on the prevention and control of physical, chemical, and biological hazards common to most projects and facilities is presented in the **General EHS Guidelines**.

Occupational health and safety issues associated with the construction and operation of roads primarily include the following:

- Physical hazards
- Chemical hazards
- Noise

### **Physical Hazards**

Road construction and maintenance personnel, as well as landscaping workers maintaining vegetation in the rights-of-way, can be exposed to a variety of physical hazards, principally from operating machinery and moving vehicles but also working at elevation on bridges and overpasses. Other physical hazards (e.g. exposure to weather elements, noise, work in confined spaces, trenching, contact with overhead power lines, falls from machinery or structures, and risk of falling objects) are discussed in the **General EHS Guidelines**.

Management practices to prevent and control physical hazards include:

#### *Moving Equipment and Traffic Safety*

- Development of a transportation management plan for road repairs that includes measures to ensure work zone safety for construction workers and the traveling public;
- Establishment of work zones to separate workers on foot from traffic and equipment by:
  - Routing of traffic to alternative roads when possible
  - Closure of lanes and diversion of traffic to the remaining lanes if the road is wide enough (e.g. rerouting of all traffic to one side of a multi-lane highway)
  - Where worker exposure to traffic cannot be completely eliminated, use of protective barriers to shield workers

from traffic vehicles, or installation of channeling devices (e.g. traffic cones and barrels) to delineate the work zone

- Regulation of traffic flow by warning lights, avoiding the use of flaggers if possible
- Design of the work space to eliminate or decrease blind spots
- Reduction of maximum vehicle speeds in work zones;
- Training of workers in safety issues related to their activities, such as the hazards of working on foot around equipment and vehicles; and safe practices for work at night and in other low-visibility conditions, including use of high-visibility safety apparel and proper illumination for the work space (while controlling glare so as not to blind workers and passing motorists).

#### *Elevated and Overhead Work*

- The area around which elevated work is taking place should be barricaded to prevent unauthorized access. Working under personnel on elevated structures should be avoided;
- Hoisting and lifting equipment should be rated and properly maintained, and operators trained in their use. Elevating platforms should be maintained and operated according to established safety procedures including use of fall protection measures (e.g. railings); equipment movement protocols (e.g. movement only when the lift is in a retracted position); repair by qualified individuals; and installation of locks to avoid unauthorized use by untrained individuals;
- Ladders should be used according to pre-established safety procedures for proper placement, climbing, standing, as well as the use of extensions.

#### *Fall Protection*

- Implementation of a fall protection program that includes training in climbing techniques and use of fall protection

measures; inspection, maintenance, and replacement of fall protection equipment; and rescue of fall-arrested workers, among others;

- Establishment of criteria for use of 100 percent fall protection (typically when working over 2 meters above the working surface, but sometimes extended to 7 meters, depending on the activity). The fall protection system should be appropriate for the structure and necessary movements, including ascent, descent, and moving from point to point;
- Installation of fixtures on bridge components to facilitate the use of fall protection systems;
- Safety belts should be not less than 16 millimeters (mm) (5/8 inch) two-in-one nylon or material of equivalent strength. Rope safety belts should be replaced before signs of aging or fraying of fibers become evident;
- When operating power tools at height, workers should use a second (backup) safety strap.

## Chemical Hazards

Chemical hazards in road construction, operations, and maintenance activities may be principally associated with exposures to dust during construction and paving activities; exhaust emissions from heavy equipment and motor vehicles during all construction and maintenance activities (including during work in tunnels or in toll collection booths); potentially hazardous dust generated during bridge paint removal; herbicide use during vegetation management; and diesel fuel used as a release and cleaning agent for paving equipment. General recommendations for hazardous materials management and chemicals hazard management are provided in the **General EHS Guidelines**.

Recommendations specific to road projects include:

- Use of millers and pavers with exhaust ventilation systems and proper maintenance of such systems to maintain worker exposure to crystalline silica (millers and grinders) and asphalt fumes (pavers) below applicable occupational exposure levels;
- Use of the correct asphalt product for each specific application, and ensuring application at the correct temperature to reduce the fuming of bitumen during normal handling;
- Maintenance of work vehicles and machinery to minimize air emissions;
- Reduction of engine idling time in construction sites;
- Use of extenders or other means to direct diesel exhaust away from the operator;
- Ventilation of indoor areas where vehicles or engines are operated, or use of exhaust extractor hose attachments to divert exhaust outside;
- Provision of adequate ventilation in tunnels or other areas with limited natural air circulation;
- Installation of tollbooth ventilation and air filtration systems;
- Use of protective clothing when working with cutbacks (a mixture of asphalt and solvents for the repair of pavement), diesel fuel, or other solvents;
- Use of dustless sanding and blasting equipment and special containment measures for paint removal activities<sup>28</sup>. Avoiding the use of lead-containing paint and using appropriate respiratory protection when removing paints (including those containing lead in older installations) or when cutting galvanized steel.

<sup>28</sup> Examples of enclosures used in paint removal activities include total enclosures with dust collector systems (for abrasive blasting), impermeable curtains (for wet abrasive blasting), or vacuum equipped power and blasting tools (Minnesota Pollution Control Agency <http://www.pca.state.mn.us/air/lead-class.htm>)

## Noise

Construction and maintenance personnel may be potentially exposed to extremely high levels of noise from heavy equipment operation and from working in proximity to vehicular traffic. As most of these noise sources cannot be prevented, control measures should include the use of personal hearing protection by exposed personnel and implementation of work rotation programs to reduce cumulative exposure. Additional recommendations on the management of occupational noise are provided in the **General EHS Guidelines**.

### 1.3 Community Health and Safety

Community health and safety issues during the construction of roads are common to those at most large construction sites, and are discussed in the **General EHS Guidelines**. These impacts include, among others, dust, noise, and vibration from construction vehicle transit, and communicable disease associated with the influx of temporary construction labor. Significant community health and safety issues associated with road projects may also include:

- Pedestrian safety
- Traffic safety
- Emergency preparedness

#### Pedestrian Safety

Pedestrians and bicyclists are at greatest risk of serious injury from collisions with moving vehicles. Children are generally the most vulnerable due to lack of experience and knowledge of traffic related hazards, their behavior while at play, and their small size making them less visible to motorists. Recommended pedestrian safety management strategies include the following:

- Provision of safe corridors along the road alignment and construction areas, including tunnels and bridges (e.g. paths

separated from the roadway), and safe crossings (preferably over or under the roadway) for pedestrians and bicyclists during construction and operation. Crossing locations should take into account community preferences, including those related to convenience or personal safety (e.g. the prevalence of crime at potential crossing point locations).

- Installation of barriers (e.g. fencing, plantings) to deter pedestrian access to the roadway except at designated crossing points;
- Installation and maintenance of speed control and traffic calming devices at pedestrian crossing areas;
- Installation and maintenance of all signs, signals, markings, and other devices used to regulate traffic, specifically those related to pedestrian facilities or bikeways.<sup>29</sup>

#### Traffic Safety

Collisions and accidents can involve a single or multiple vehicles, pedestrians or bicyclists, and animals. Many factors contribute to traffic accidents. Some are associated with the behavior of the driver or the quality of the vehicle, while others are linked to the road design, or construction and maintenance issues.

Recommendations to prevent, minimize, and control risks to the community from traffic accidents include:

- Installation and maintenance of all signs, signals, markings, and other devices used to regulate traffic, including posted speed limits, warnings of sharp turns, or other special road conditions;<sup>30</sup>
- Setting of speed limits appropriate to the road and traffic conditions;

<sup>29</sup> As required by public agencies with jurisdiction over the project site. In their absence, project developers and operators should refer to sources from well developed regulatory frameworks such as the US Code of Federal Regulations (CFR) Part 655, Subpart F and the Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD, 2003)

<sup>30</sup> Based on local regulatory requirements or, in their absence, sources such as the US Code of Federal Regulations (CFR) Part 655, Subpart F and the Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD, 2003)

- Design of roadways to accommodate anticipated traffic volume and flow;
- Maintenance of the road to prevent mechanical failure of vehicles due to road conditions;
- Construction of roadside rest areas at strategic locations to minimize driver fatigue;
- Installation of measures to reduce collisions between animals and vehicles (e.g. use of signs to alert drivers on road segments where animals frequently cross; construction of animal crossing structures; installation of fencing along the roadway to direct animals toward crossing structures; and use of reflectors along the roadside to deter animal crossings at night when vehicles are approaching);
- Targeting elimination of at-grade rail crossings;
- Targeting the use of a real-time warning system with signage to warn drivers of congestion, accidents, adverse weather or road conditions, and other potential hazards ahead.

### Emergency Preparedness

Emergency situations most commonly associated with road operations include accidents involving single or multiple vehicles, pedestrians, and / or the release of oil or hazardous materials. Road operators should prepare an emergency preparedness and response plan in coordination with the local community and local emergency responders to provide timely first aid response in the event of accidents and hazardous materials response in the event of spills.

## 2.0 Performance Indicators and Monitoring

### 2.1 Environment

#### Emissions and Effluent Guidelines

Roads do not typically give rise to significant point source air emissions or effluents. Instead, operators should apply the principles and guidelines described above and in the **General EHS Guidelines**, especially with regard to emissions or effluents from road maintenance facilities.

#### Environmental Monitoring

Environmental monitoring programs for this sector should be implemented to address all activities that have been identified to have potentially significant impacts on the environment, during normal operations and upset conditions. Monitoring frequency should be sufficient to provide representative data for the parameter being monitored. Monitoring should be conducted by trained individuals following monitoring and record-keeping procedures and using properly calibrated and maintained equipment. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Additional guidance on applicable sampling and analytical methods for emissions and effluents is provided in the **General EHS Guidelines**.

### 2.1 Occupational Health and Safety

#### Occupational Health and Safety Guidelines

Occupational health and safety performance should be evaluated against internationally published exposure guidelines, of which examples include the Threshold Limit Value (TLV®)

occupational exposure guidelines and Biological Exposure Indices (BEIs®) published by American Conference of Governmental Industrial Hygienists (ACGIH),<sup>31</sup> the Pocket Guide to Chemical Hazards published by the United States National Institute for Occupational Health and Safety (NIOSH),<sup>32</sup> Permissible Exposure Limits (PELs) published by the Occupational Safety and Health Administration of the United States (OSHA),<sup>33</sup> Indicative Occupational Exposure Limit Values published by European Union member states,<sup>34</sup> or other similar sources

guidance on occupational health and safety monitoring programs is provided in the **General EHS Guidelines**.

## Accident and Fatality Rates

Projects should try to reduce the number of accidents among project workers (whether directly employed or subcontracted) to a rate of zero, especially accidents that could result in lost work time, different levels of disability, or even fatalities. Facility rates may be benchmarked against the performance of facilities in this sector in developed countries through consultation with published sources (e.g. US Bureau of Labor Statistics and UK Health and Safety Executive)<sup>35</sup>.

## Occupational Health and Safety Monitoring

The working environment should be occupational hazards relevant to the specific project. Monitoring should be designed and implemented by accredited professionals<sup>36</sup> as part of an occupational health and safety monitoring program. Facilities should also maintain a record of occupational accidents and diseases and dangerous occurrences and accidents. Additional

<sup>31</sup> Available at: <http://www.acgih.org/TLV/> and <http://www.acgih.org/store/>

<sup>32</sup> Available at: <http://www.cdc.gov/niosh/npg/>

<sup>33</sup> Available at:  
[http://www.osha.gov/pls/oshaweb/owadisp.show\\_document?p\\_table=STANDAR DS&p\\_id=9992](http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDAR DS&p_id=9992)

<sup>34</sup> Available at: [http://europe.osha.eu.int/good\\_practice/risks/ds/oel/](http://europe.osha.eu.int/good_practice/risks/ds/oel/)

<sup>35</sup> Available at: <http://www.bls.gov/iif/> and  
<http://www.hse.gov.uk/statistics/index.htm>

<sup>36</sup> Accredited professionals may include Certified Industrial Hygienists, Registered Occupational Hygienists, or Certified Safety Professionals or their equivalent.

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## **Annex A: General Description of Industry Activities**

Road project infrastructure typically includes the rights-of-way, the roadway, junctions, tunnels, bridges, maintenance facilities, parking lots, and toll plazas in the case of toll roads. Road projects may include provisions for bicycles and pedestrians, such as designated bicycle lanes or shared-use paths separated from the roadway. Some road projects may also involve the construction and operation of vehicle service areas.

Direct land requirements for roads typically range from about 9 hectares (ha) per kilometer (km) for two lanes in each direction to 12 ha / km for four lanes in each direction.<sup>37</sup> The width of the rights-of-way may need to be sufficient to include traffic lanes, shoulders, grass strips, sidewalks and cycle lanes, public utility facilities, and outer slopes. In hilly terrain, the required right-of-way varies considerably as the roadway passes areas that require landscapes to be cut and filled, however tunnels are often preferred to avoid steep up and down sections on roads.

### **Design and Construction**

Generally, modern roads are constructed as all-weather roads with a hard surface pavement, usually asphalt or concrete. A paved roadway typically consists of three layers above the sub-grade: the sub-base, base course, and wearing course. Each layer is compacted by a roller before proceeding with the next course.

#### *Sub-grade, Sub-base, and Base layers*

The sub-grade is earth that has been graded to the desired elevation. The soil may need to be amended with stabilizing additives (e.g. lime, portland cement, or fly ash) to provide adequate, uniform support to the overlying road structure.

The sub-base layer is designed to evenly spread the load of the pavement and the traffic to the ground below. Both bound and unbound materials are used for construction of sub-base. Unbound materials consist of aggregates which are loose and do not bind or adhere to neighboring particles when laid and compacted. The material is typically crushed stone, slag, or concrete. For bound materials, a binder, usually cement, is added to bind the aggregates together, thus allowing heavier loads but also reducing drainage. Crushed stone, slag, and building material can be used as components in bound materials.

The base course is the strengthening layer of the pavement. The material used is similar to that of the sub-base, but the size of particles is more uniform. Asphalt or concrete can be used as a binding medium.

#### *Wearing layer*

The wearing course is the top layer of asphalt or concrete. The top layer needs to be even to provide a smooth ride for cars and trucks. Asphalt is the most common material for the wearing course. The basic input materials used in asphalt preparation are hot liquid bitumen and aggregates (e.g. sand and crushed stone).

#### *Asphalt*

Hot mix asphalt is a highly technical mixture of strictly specified materials (e.g. the tolerance for the aggregates is often less than 5 percent for the shape, size, hardness, and wear index) The variety of mix types is practically limitless, depending on its position in the road structure (e.g. base or wearing course), on its particular function (e.g. intensity of traffic, anti-skid properties, noise reduction), on climatic conditions (e.g. from freezing to high temperatures), and on the nature of raw materials locally available (e.g. limestone or granite quarries, types of bitumen).

<sup>37</sup> EEA, 1998.

Other materials, such as broken asphalt (taken from a road that has been ripped up), sulphur, rubber, and foundry sands can be added to the basic mix without compromising the final asphalt quality.

Asphalts are grouped by their content and the size of stones (aggregates). Many types of asphalts have been developed to satisfy desired requirements depending on climate conditions, traffic loads, and other specific parameters. Two types of asphalt that are common in modern road work are stone mastic asphalt (SMA) and porous asphalt.

SMA consists of a coarse aggregate skeleton bound with mastic consisting of crushed rock fines, filler, and bitumen. The stone to stone contact of the coarse aggregate ensures a very durable matrix that is resistant to age hardening, and capable of high resistance to deformation. Consequently, it is resistant to cracking, ravelling, and damage by moisture.

Increasing traffic volumes, particularly in countries with wet climates, have led to the development of porous asphalt (PA). PA consists primarily of gap-graded aggregates bound together by a polymer modified binder to form a matrix with interconnecting voids through which water can pass.

The main difference between SMA and PA is in the percentage of voids in the mix. PA has a void content of at least 20 percent compared with 3 to 6 percent for SMA. This higher void content means that the PA greatly improves the rate of surface water drainage, thereby reducing spray and headlight glare in wet weather, improving skid resistance, and reducing the tendency for hydroplaning. PA typically also generates lower tire / pavement noise than other wearing course materials.

Asphalt is normally applied within 30-50 km of the mixing plant, however transport up to 100 km may be necessary in some cases.

### *Concrete*

Concrete may be chosen for the wearing course, especially for roads carrying high traffic volume and heavy truck traffic, principally because of its durability, long life (usually 20 – 30 years), and generally lower maintenance needs compared to asphalt paving. Concrete typically generates higher levels of tire / pavement noise and is more expensive to install than asphalt.

The sub-grade, sub-base, and base layers supporting concrete paving are similar to those described above for asphalt paving. Because of the rigidity of concrete pavement, loads are spread over a large area and pressures on the subgrade are relatively low. A sub-base may be omitted when constructing concrete roads designed for light traffic. For large road projects, the concrete slab is usually laid down by slip-form paving equipment, which form and consolidate fresh concrete as they move along the right-of-way. The pavement surface is textured to enhance wet and dry weather traction. Contraction and expansion joints are included at regular intervals to relieve stresses and prevent cracking of the concrete slab.

### *Pavement Marking*

Pavement striping is used for lane stripes and other pavement markings to guide motorists. Other pavement markers are used to supplement traffic signs. Markers may either be surface mounted (raised) or placed in recessed slots in the pavement. Markers are applied using bitumen / epoxy adhesives.

### *Toll stations*

Toll stations may be manually or electronically operated or a mixture of both. To avoid prolonged stops at the tollgates, the roadway expands into a toll plaza with several lanes. The plaza design allows for traffic to safely separate and decelerate to the collection point and then accelerate and merge with the traffic flow again. Manual collection of tolls is relatively slow, and

therefore requires more toll booths / lanes than are required for electronic systems to process the same number of vehicles.

## Operation and Maintenance

Operation and maintenance activities are numerous but mainly include road repair, snow and ice removal, bridge maintenance, and vegetation maintenance.

Asphalt pavement is susceptible to cracking and other breakdowns that have to be repaired. Asphalt emulsions are usually used to fill up small cracks. Cutbacks, which are a mixture of asphalt and petroleum solvents, are not used as frequently because of potential environmental effects of the solvents. Repair tasks include equipment operation, sweeping, application of asphalt, and compaction rolling.

The most common location for repairs of concrete roadways is at the longitudinal joints, where moisture has the opportunity to enter the pavement system. Repairs are typically conducted by sawing through and removing the deteriorated concrete. The existing base material is compacted, and additional material added if necessary. Load transfer is re-established in the patched area by means of reinforcement (e.g. tiebars and dowels). The new concrete is textured to match the surface of the existing roadway. Diamond grinding is also used to restore surface properties (e.g. reducing bumps and dips and restoring surface roughness).

When the road surface deteriorates to the extent that spot repairs and surface treatments are not useful, resurfacing is necessary. For asphalt pavement, resurfacing is most often accomplished by use of milling machines, which remove the top layer of pavement. The removed pavement can be transported off site and crushed or otherwise processed to make it useable as sub-base or other material.

Often, the removed pavement is ground at the job site, mixed with beneficiating additives (e.g. virgin aggregate, binder, and / or softening or rejuvenating agents to improve binder properties), and then used for re-paving the roadway. Milling and paving of asphalt roads is often completed in a single pass. Resurfacing of a concrete roadway entails breaking and removal of the concrete, compacting and amending the base material as necessary, and then re-paving. Removed concrete is usually crushed and recycled as sub-base material.

Snow / ice removal consists of plowing snow and ice from bridges, roadways, and shoulders. Wide ditches facilitate storage for plowed snow, which otherwise would be piled along the edge of the roadway or require removal. De-icing with chemicals (e.g. common salt [sodium chloride] or magnesium chloride) is used to facilitate safe driving. Alternatives to chloride salts include calcium magnesium acetate and potassium acetate. Spreading of sand or crushed stone is also used for increasing traffic safety. However, sanding is less effective on highways because the sand can be displaced by vehicles traveling at high speeds.<sup>38</sup>

Steel bridges are generally painted with a multi-coat paint system to resist corrosion. In order to keep a high-quality protection against deterioration, new paint has to be applied regularly. If the old paint is in good condition it can be overcoated, otherwise it has to be removed before the new paint can be applied. Old paints may contain lead.

Vegetation in the rights of way requires periodic maintenance to enhance aesthetics and to prevent potential safety hazards (e.g. reduced visibility, obstruction of signs, and debris in the roadway). Vegetation maintenance typically includes mechanical mowing, trimming, removal of brush, cleanup, and removal of trees when necessary.

<sup>38</sup> University of New Hampshire, 2001.