Abstract
- The State of Qatar has a particular problem in securing natural aggregates, which are used extensively in railroad and concrete applications.
- Currently, Qatar is depending on neighbouring countries to secure its need for natural aggregates. However, the importation of aggregates has become costly to Qatar because of the blockade.
- On the other hand, more than 400,000 tons of steel slag are being generated annually by Qatar steel companies. One of the potential applications of steel slag includes railway ballast.
- Therefore, there is a substantial need of examining the feasibility for utilizing steel slag as railroad ballast.

General Properties
- Physical State: Solid.
- Color: Dark gray.
- Shape: Very rough and porous surface with high angularity.
- Odor: Odorless.
- Solubility: Insoluble in water, oil, and solvents.

Physical / Mechanical Properties:

<table>
<thead>
<tr>
<th>Physical/Mechanical Property</th>
<th>QCS Spec 2014</th>
<th>Steel Slag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity (g/cm³)</td>
<td>2.308</td>
<td>2.3014</td>
</tr>
<tr>
<td>Unit Weight, (g/cm³)</td>
<td>265.6</td>
<td>1852.7</td>
</tr>
<tr>
<td>Water Absorption for Coarse Aggregates (%)</td>
<td>1.0870</td>
<td>0.2600</td>
</tr>
<tr>
<td>Los Angeles Abrasion (%)</td>
<td>14.672</td>
<td>7.948</td>
</tr>
<tr>
<td>Sand Equivalent for Coarse Aggregates (%)</td>
<td>95</td>
<td>73</td>
</tr>
<tr>
<td>Soundness Loss for Coarse Aggregates (%)</td>
<td>0.1550</td>
<td>2.173</td>
</tr>
<tr>
<td>Maximum Dry Density, (g/cm³)</td>
<td>2.535</td>
<td>2.436</td>
</tr>
<tr>
<td>California Bearing Ratio, (%)</td>
<td>239</td>
<td>129</td>
</tr>
</tbody>
</table>

Chemical Properties
- The mineral composition of SSA could differ depending upon the procedure of steel production. Major minerals in our steel slag were aragonite, calcite, and gypsum.

Objectives
1. To investigate the feasibility of using steel slag aggregate (SSA) produced in Qatar in railway construction.
2. To perform physical, chemical, environmental, mechanical, and durability tests on SSA produced in Qatar.
3. To reduce the importation of natural aggregates.

Benefits
1. Provide an alternative for providing high quality aggregates at low costs and minimal impact on the environment.
2. Allows for future sustainability and economic development of the country by relying on its own resources.
3. To reduce the importation of natural aggregates.

Potential Customers/Market
1. Qatar Rail.
2. Construction Companies.

Major Impact
1. Successful research outcomes can lead to the full commercialization of local SSA as the country progresses in the construction of its infrastructure.

RESEARCH BACKGROUND
- Properties of SSA are compared with other natural aggregates and the requirements of Qatar Construction Standards (QCS).

TECHNICAL APPROACH
- No recorded research was conducted on Qatar’s SSA as a railroad ballast.
- Research is, thus, needed to determine the physical, chemical, environmental, mechanical, and durability properties of Qatar’s SSA so that it can match the use as a ballast material.

Approach/Solution
- Physical and chemical tests of SSA is conducted in accordance with international standards, such as ASTM Standards.
- The results are compared with QCS requirements.

CONSTRUCTION OF QATAR’S RAIL USING WASTE STEEL SLAG AS A BALLAST MATERIAL (UREP 22-006-2-002)

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Production Process of Steel Slag

Steel Slag Aggregate (SSA)

Physical/Mechanical Properties:

<table>
<thead>
<tr>
<th>Physical / Mechanical Property</th>
<th>SSA</th>
<th>Gabbro</th>
<th>Limestone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk Specific Gravity (g/cm³)</td>
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<td>2.3014</td>
<td>2.4944</td>
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<tr>
<td>Unit Weight, (g/cm³)</td>
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<td>1852.7</td>
<td>1492.2</td>
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<tr>
<td>Water Absorption for Coarse Aggregates (%)</td>
<td>0.26008</td>
<td>0.26008</td>
<td>2.8641</td>
</tr>
<tr>
<td>Los Angeles Abrasion (%)</td>
<td>7.948</td>
<td>7.948</td>
<td>26.988</td>
</tr>
<tr>
<td>Sand Equivalent for Coarse Aggregates (%)</td>
<td>73</td>
<td>73</td>
<td>23</td>
</tr>
<tr>
<td>Soundness Loss for Coarse Aggregates (%)</td>
<td>2.173</td>
<td>2.173</td>
<td>13.73</td>
</tr>
<tr>
<td>Maximum Dry Density, (g/cm³)</td>
<td>2.536</td>
<td>2.436</td>
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</tr>
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<td>California Bearing Ratio, (%)</td>
<td>129</td>
<td>129</td>
<td>92</td>
</tr>
</tbody>
</table>

QCS Requirements for Road Base & Subbase Application

Steel Slag Aggregate IC Analysis for Anions

CHEMICAL PROPERTIES
- The TCLP involves continuous mixing of a 20:1 liquid-to-solid ratio solutions, and an 18-hour equilibration time. After that, all samples were filtered and the remaining solutions, or leachate, was taken for ion chromatography (IC) analysis.

KEY OUTCOMES & FUTURE PLANS

Major Outcomes
1. SSA showed a better performance than the imported aggregates in terms of water absorption, Los Angeles abrasion, and magnesium sulphate soundness tests.
2. SSA meets the QCS 2014 requirements in mechanical and physical tests for both base and subbase applications.
3. Chemically, SSA was similar in composition to the imported aggregates and contained very low concentrations of heavy metals; however, it contained some unacceptable concentration of some materials like sulfate that can make the usage environmentally harmful.

Possible Future Plans
1. More dynamic tests, such as vibration and noise resistance, to gain a deeper understanding into the serviceability of SSA in railroad applications.