IMPORT LIBRARIES

In [1]:
```python
import numpy as np
import pandas as pd
import matplotlib.pyplot as pyp
import seaborn as sns
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
import scipy.stats as stats
from sklearn.metrics import  mean_squared_error
```

In [2]:
```python
import warnings
warnings.filterwarnings('ignore')
```

DATA IMPORTING

In [3]:
```python
data = pd.read_csv('concrete_data.csv')
data
```

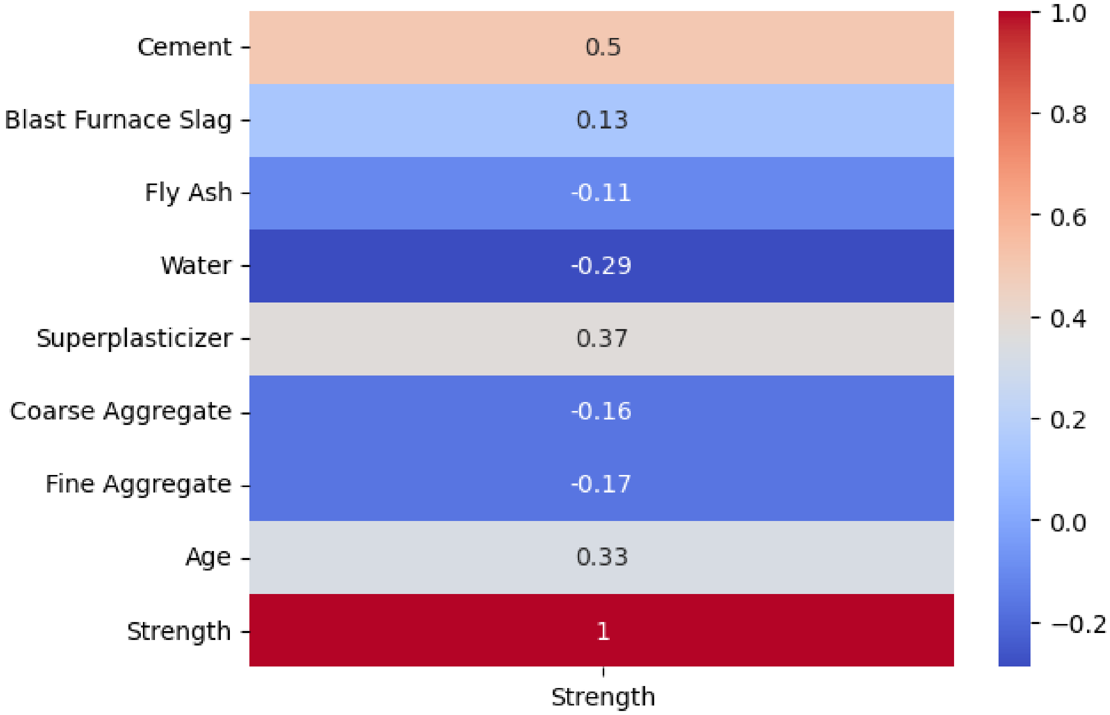
Out[3]:

	Cement	Blast Furnace Slag	Fly Ash	Water	Superplasticizer	Coarse Aggregate	Fine Aggregate	Age	Strength
0	540.0	0.0	0.0	162.0	2.5	1040.0	676.0	28	79.99
1	540.0	0.0	0.0	162.0	2.5	1055.0	676.0	28	61.89
2	332.5	142.5	0.0	228.0	0.0	932.0	594.0	270	40.27
3	332.5	142.5	0.0	228.0	0.0	932.0	594.0	365	41.05
4	198.6	132.4	0.0	192.0	0.0	978.4	825.5	360	44.30
...	...	...	...	...	...	...	...	...	...
1025	276.4	116.0	90.3	179.6	8.9	870.1	768.3	28	44.28
1026	322.2	0.0	115.6	196.0	10.4	817.9	813.4	28	31.18
1027	148.5	139.4	108.6	192.7	6.1	892.4	780.0	28	23.70
1028	159.1	186.7	0.0	175.6	11.3	989.6	788.9	28	32.77
1029	260.9	100.5	78.3	200.6	8.6	864.5	761.5	28	32.40

1030 rows × 9 columns

CORRELATING HIGHLY DEPENDENT FEATURES

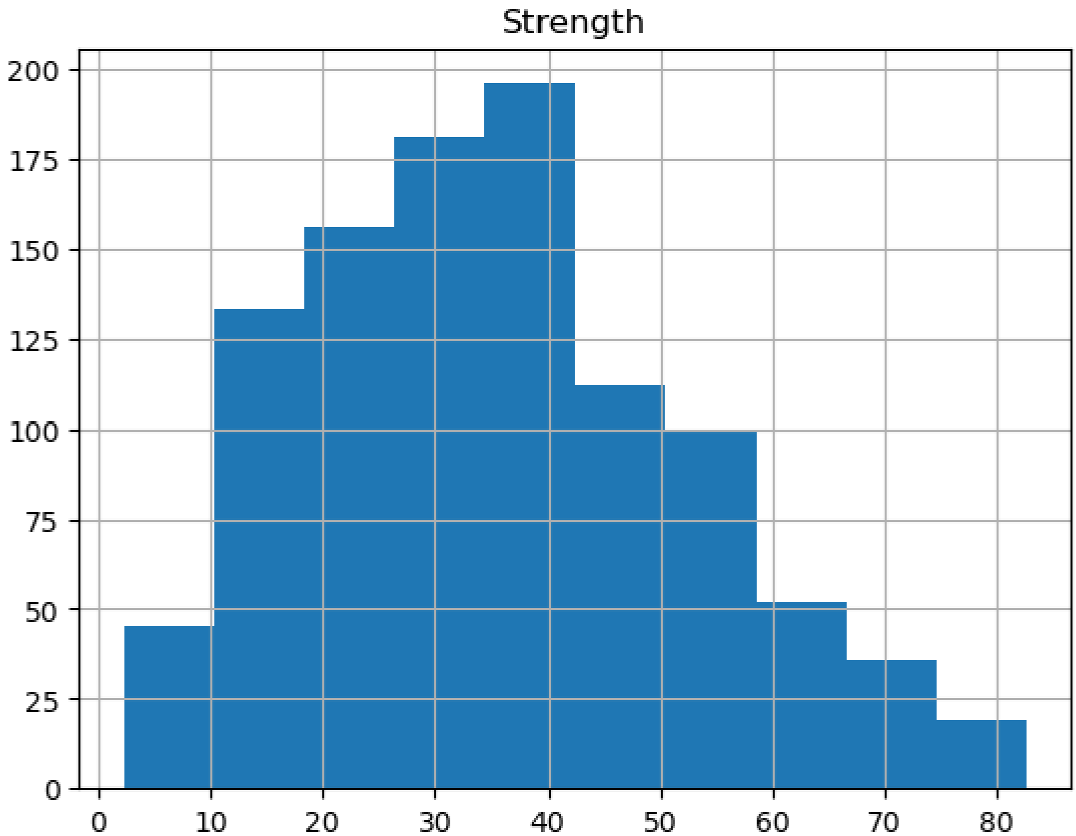
In [4]:
```
sns.heatmap(data.corr()['Strength'].to_frame(),cmap='coolwarm',annot=True)
pyp.show()
```



ANALYSING LABEL

In [5]:

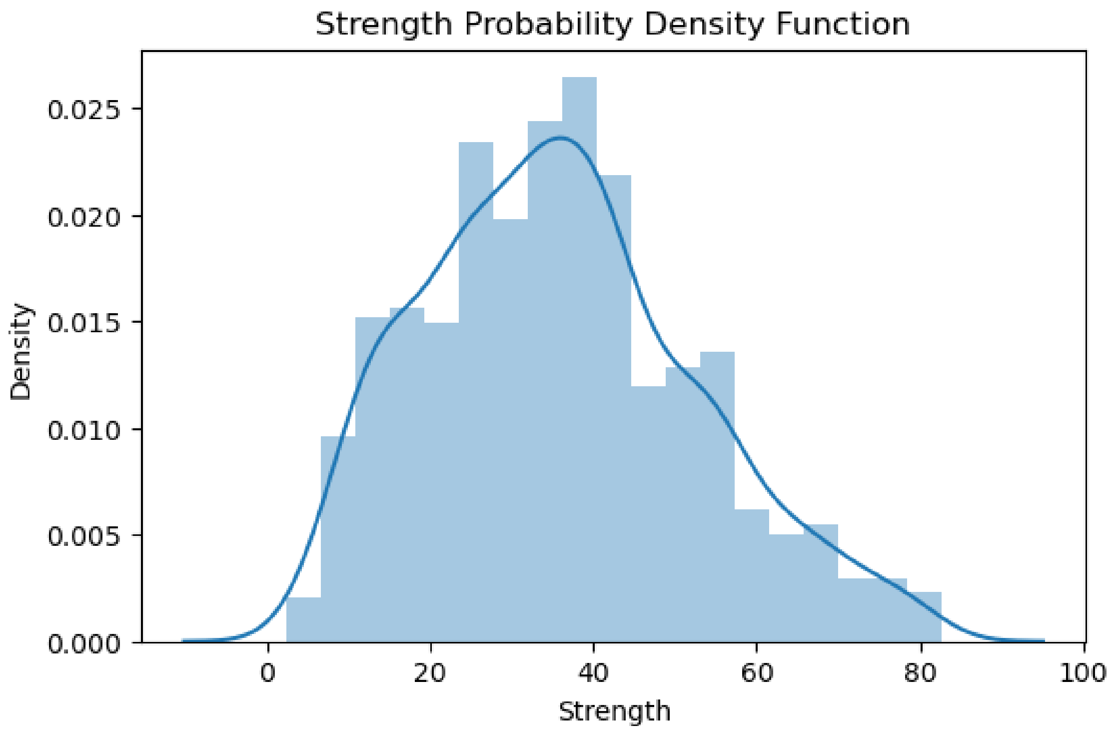
```
data.hist('Strength')
pyp.show()
```



DISTRIBUTION OF LABEL

In [6]:

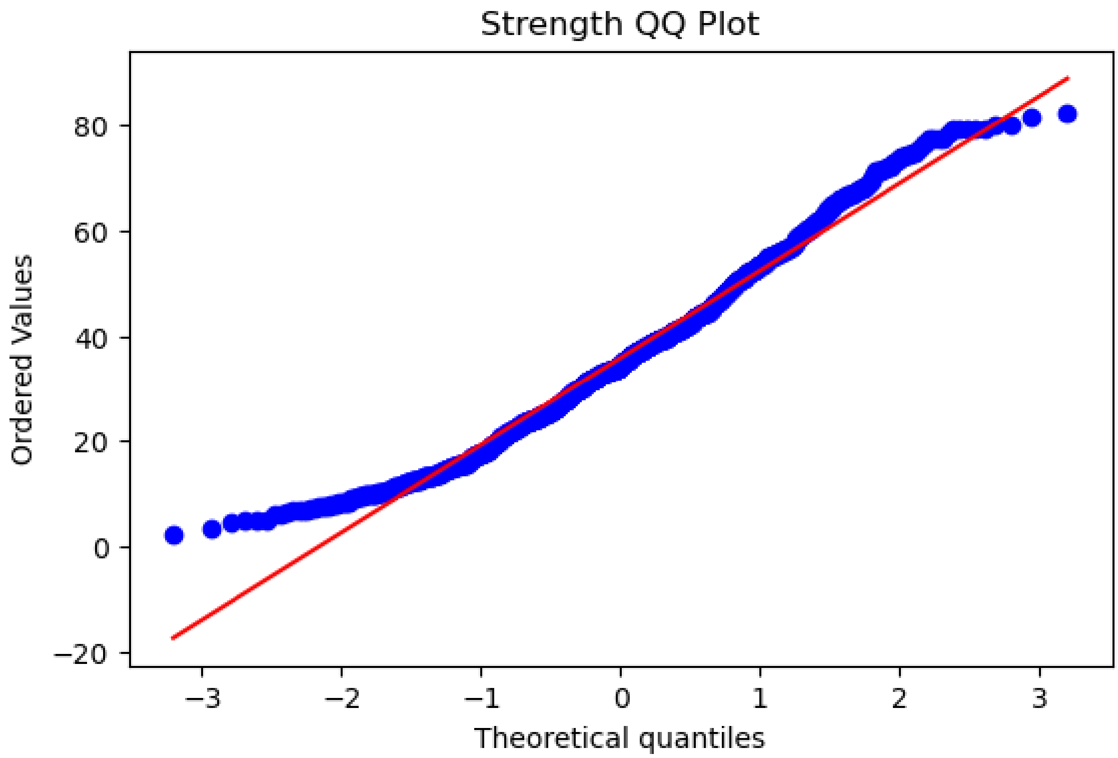
```
pyp.figure(figsize=(14,4))
pyp.subplot(121)
sns.distplot(data['Strength'])
pyp.title('Strength Probability Density Function')
pyp.show()
```



RELATION OF DATA POINTS WITH NORMAL DISTRIBUTION

In [7]:

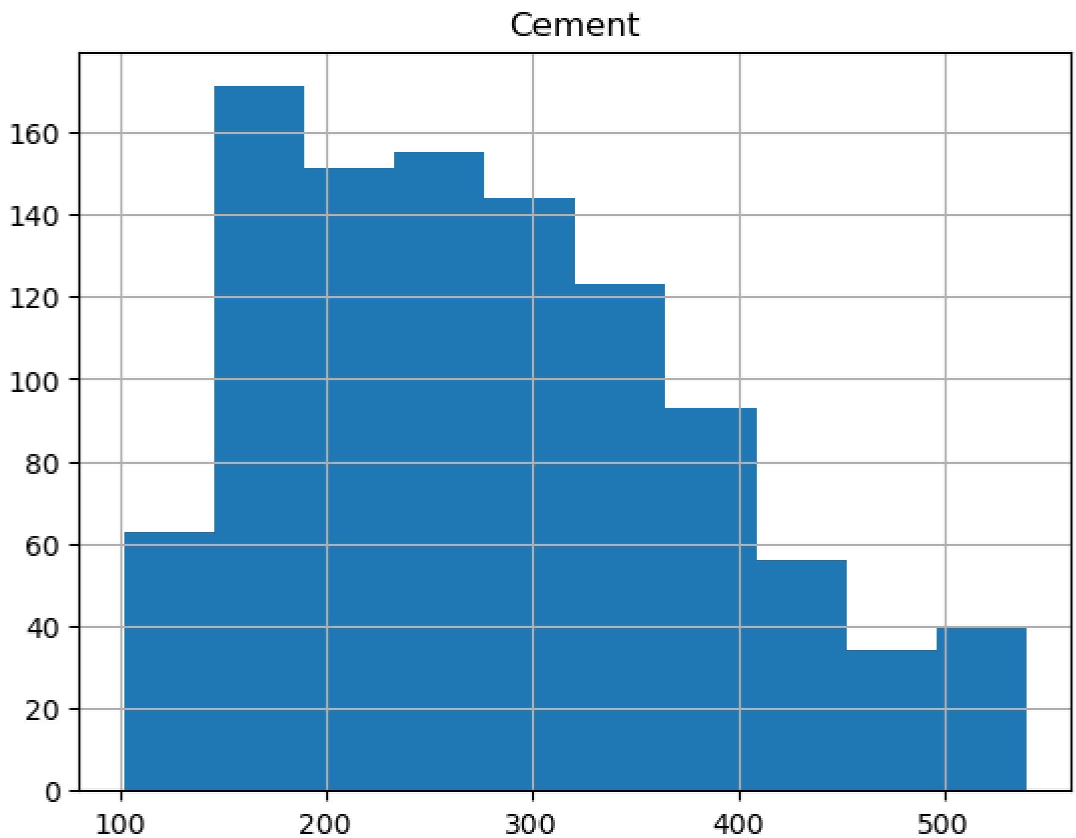
```
pyp.figure(figsize=(14,4))
pyp.subplot(121)
stats.probplot(data['Strength'],dist='norm',plot=pyp)
pyp.title('Strength QQ Plot')

pyp.show()
```



ANALYSING ON DEPENDENT FEATURES

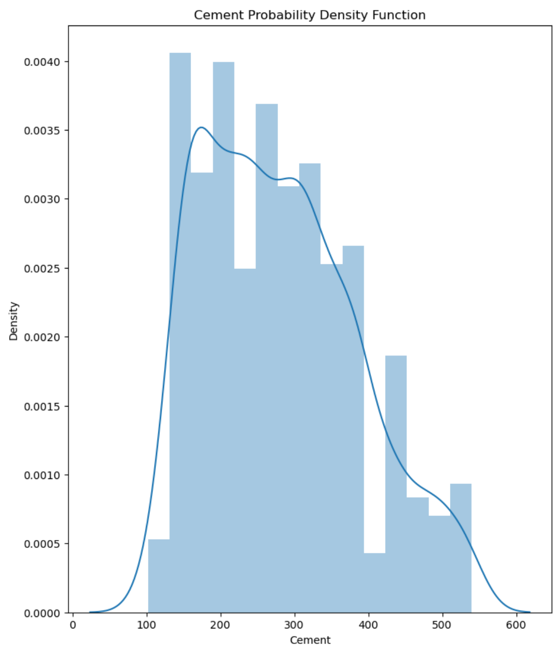
In [8]:

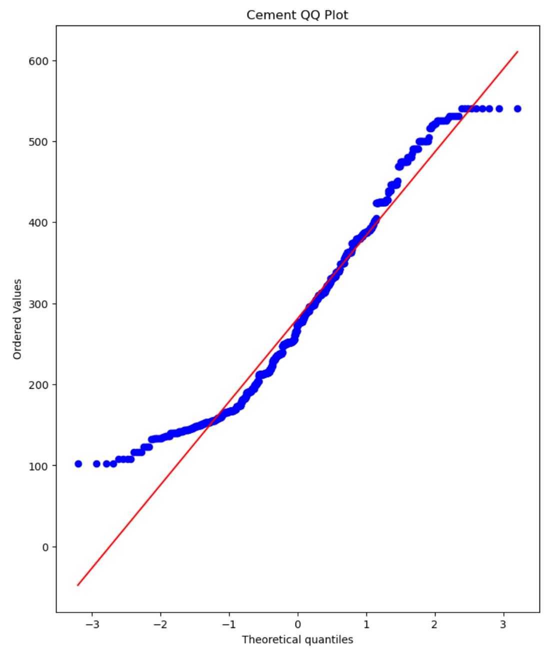
```
data.hist('Cement')
pyp.show()
```



In [9]:

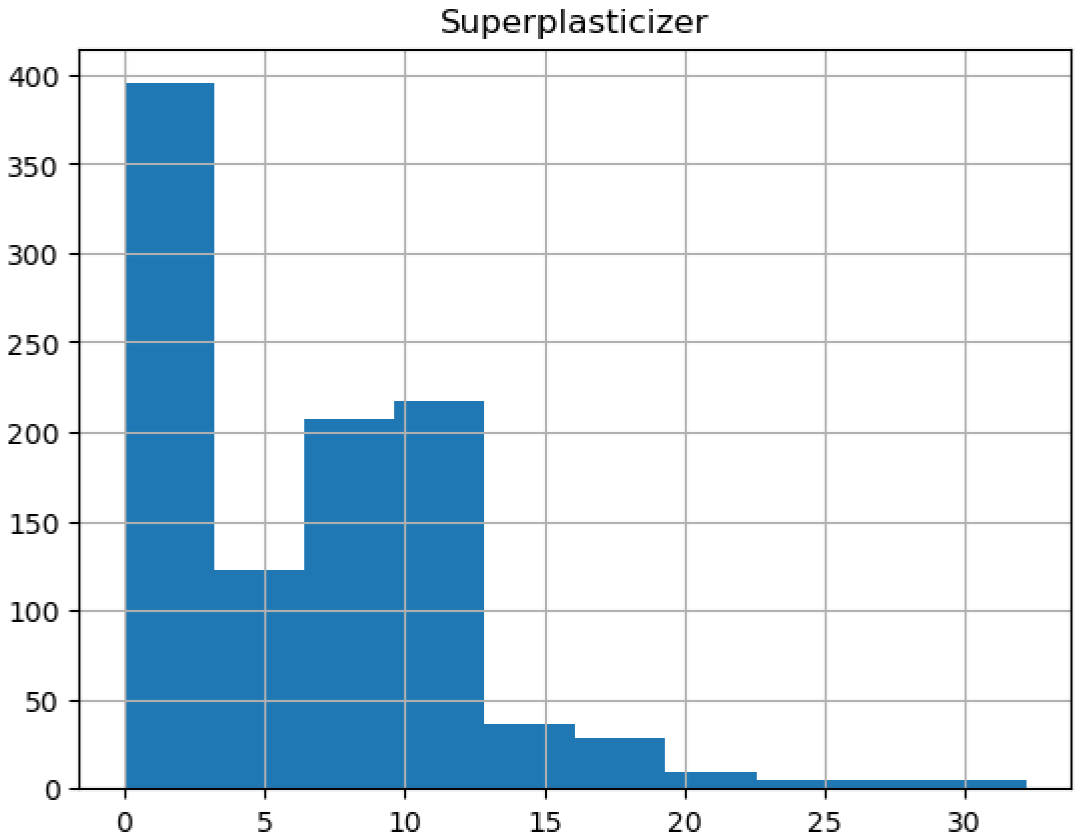
```
pyp.figure(figsize=(18,10))
pyp.subplot(121)
sns.distplot(data['Cement'])
pyp.title('Cement Probability Density Function')

pyp.subplot(122)
stats.probplot(data['Cement'],dist='norm',plot=pyp)
pyp.title('Cement QQ Plot')

pyp.show()
```





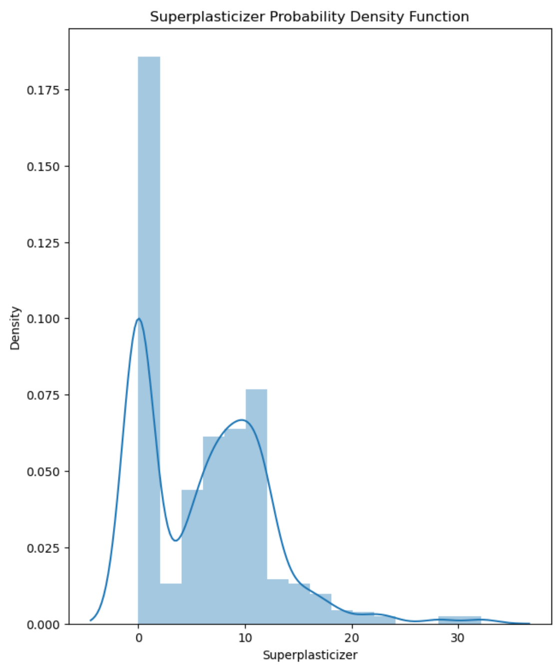
In [10]:

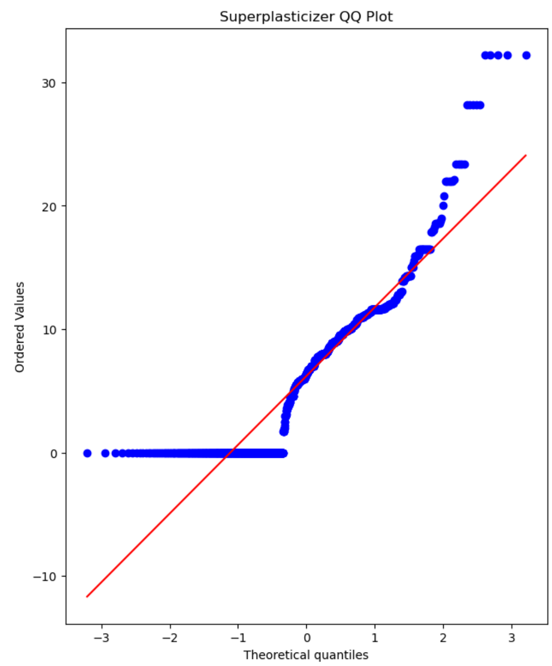
```
data.hist('Superplasticizer')
pyp.show()
```



In [11]:

```
pyp.figure(figsize=(16,9))
pyp.subplot(121)
sns.distplot(data['Superplasticizer'])
pyp.title('Superplasticizer Probability Density Function')

pyp.subplot(122)
stats.probplot(data['Superplasticizer'],dist='norm',plot=pyp)
pyp.title('Superplasticizer QQ Plot')

pyp.show()
```





In [12]:
```
data
```

Out[12]:

	Cement	Blast Furnace Slag	Fly Ash	Water	Superplasticizer	Coarse Aggregate	Fine Aggregate	Age	Strength
0	540.0	0.0	0.0	162.0	2.5	1040.0	676.0	28	79.99
1	540.0	0.0	0.0	162.0	2.5	1055.0	676.0	28	61.89
2	332.5	142.5	0.0	228.0	0.0	932.0	594.0	270	40.27
3	332.5	142.5	0.0	228.0	0.0	932.0	594.0	365	41.05
4	198.6	132.4	0.0	192.0	0.0	978.4	825.5	360	44.30
...	...	...	...	...	...	...	...	...	..
1025	276.4	116.0	90.3	179.6	8.9	870.1	768.3	28	44.28
1026	322.2	0.0	115.6	196.0	10.4	817.9	813.4	28	31.18
1027	148.5	139.4	108.6	192.7	6.1	892.4	780.0	28	23.70
1028	159.1	186.7	0.0	175.6	11.3	989.6	788.9	28	32.77
1029	260.9	100.5	78.3	200.6	8.6	864.5	761.5	28	32.40

1030 rows × 9 columns

In [13]:
```
data.Age.value_counts()
```

Out[13]:
```
28     425
3      134
7      126
56      91
14      62
90      54
100     52
180     26
91      22
365     14
270     13
360      6
120      3
1        2
Name: Age, dtype: int64
```

In [14]:
```
hold = data[data['Age']>99]['Age'].index
```

In [15]:
```
len(hold)
```

Out[15]:
```
114
```

In [16]:

```
for i in hold:
    temp = str(data.loc[i,'Age'])
    data.loc[i,'Age'] = int(temp[:-1])
```

In [17]:

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1030 entries, 0 to 1029
Data columns (total 9 columns):
 #   Column              Non-Null Count  Dtype  
---  ------              --------------  -----  
 0   Cement              1030 non-null   float64
 1   Blast Furnace Slag  1030 non-null   float64
 2   Fly Ash             1030 non-null   float64
 3   Water               1030 non-null   float64
 4   Superplasticizer    1030 non-null   float64
 5   Coarse Aggregate    1030 non-null   float64
 6   Fine Aggregate      1030 non-null   float64
 7   Age                 1030 non-null   int64  
 8   Strength            1030 non-null   float64
dtypes: float64(8), int64(1)
memory usage: 72.5 KB
```

In [18]:

```
data
```

Out[18]:

	Cement	Blast Furnace Slag	Fly Ash	Water	Superplasticizer	Coarse Aggregate	Fine Aggregate	Age	Strength
0	540.0	0.0	0.0	162.0	2.5	1040.0	676.0	28	79.9
1	540.0	0.0	0.0	162.0	2.5	1055.0	676.0	28	61.8
2	332.5	142.5	0.0	228.0	0.0	932.0	594.0	27	40.27
3	332.5	142.5	0.0	228.0	0.0	932.0	594.0	36	41.0
4	198.6	132.4	0.0	192.0	0.0	978.4	825.5	36	44.3
...	...	...	...	...	...	...	...	...	..
1025	276.4	116.0	90.3	179.6	8.9	870.1	768.3	28	44.2
1026	322.2	0.0	115.6	196.0	10.4	817.9	813.4	28	31.1
1027	148.5	139.4	108.6	192.7	6.1	892.4	780.0	28	23.7
1028	159.1	186.7	0.0	175.6	11.3	989.6	788.9	28	32.77
1029	260.9	100.5	78.3	200.6	8.6	864.5	761.5	28	32.4

1030 rows × 9 columns

In [19]:
```
data.Age.value_counts()
```
Out[19]:
```
28    425
3     134
7     126
56     91
14     62
90     54
10     52
18     26
91     22
36     20
27     13
12      3
1       2
Name: Age, dtype: int64
```

In [20]:
```
data[data['Age']<=10]
```
Out[20]:

	Cement	Blast Furnace Slag	Fly Ash	Water	Superplasticizer	Coarse Aggregate	Fine Aggregate	Age	Strength
22	139.6	209.4	0.0	192.0	0.0	1047.0	806.9	3	8.06
29	475.0	0.0	0.0	228.0	0.0	932.0	594.0	7	38.60
45	427.5	47.5	0.0	228.0	0.0	932.0	594.0	7	35.08
46	349.0	0.0	0.0	192.0	0.0	1047.0	806.9	3	15.05
48	237.5	237.5	0.0	228.0	0.0	932.0	594.0	7	26.26
...	...	...	...	...	...	...	...	...	...
810	310.0	0.0	0.0	192.0	0.0	970.0	850.0	7	14.99
815	525.0	0.0	0.0	189.0	0.0	1125.0	613.0	3	33.80
816	525.0	0.0	0.0	189.0	0.0	1125.0	613.0	7	42.42
826	480.0	0.0	0.0	192.0	0.0	936.0	721.0	3	24.39
827	522.0	0.0	0.0	146.0	0.0	896.0	896.0	7	50.51

314 rows × 9 columns

In [21]:
```
len(data)
```
Out[21]:
```
1030
```

In [22]:
```
data[data['Age']<=10]['Superplasticizer'].unique()
```
Out[22]:
```
array([ 0. , 10.1,  8.6, 16.5, 18.6, 23.4,  8.9, 32.2, 12.1, 28.2, 14.3,
       11.4, 11.6, 10.3, 15.9, 11.2, 11.1, 22. ,  9.5,  4.5,  4.6,  7.5,
        7.8,  5.7,  9.9,  6.9,  6.7,  6.1,  7. ,  5.5,  8.7, 10.4,  5.8,
        6.4,  7.6,  8.2, 10.8,  9.4, 11.8, 12.4, 12.8, 14.2, 12. , 10.2,
       11.7, 11.9,  9.6, 11.3,  8.1,  3.6,  4.1,  6.5,  7.9,  9.7,  5.3,
       13.9,  3.9,  8.5,  1.7, 10.9])
```

In [23]:
```python
data['Superplasticizer'].value_counts(bins=3)
```
Out[23]:
```
(-0.0332, 10.733]    793
(10.733, 21.467]     215
(21.467, 32.2]        22
Name: Superplasticizer, dtype: int64
```

In [24]:
```python
data.loc[data['Age'] <= 10, 'Age'] = data[data['Age'] <= 10]['Age'] + 10
```

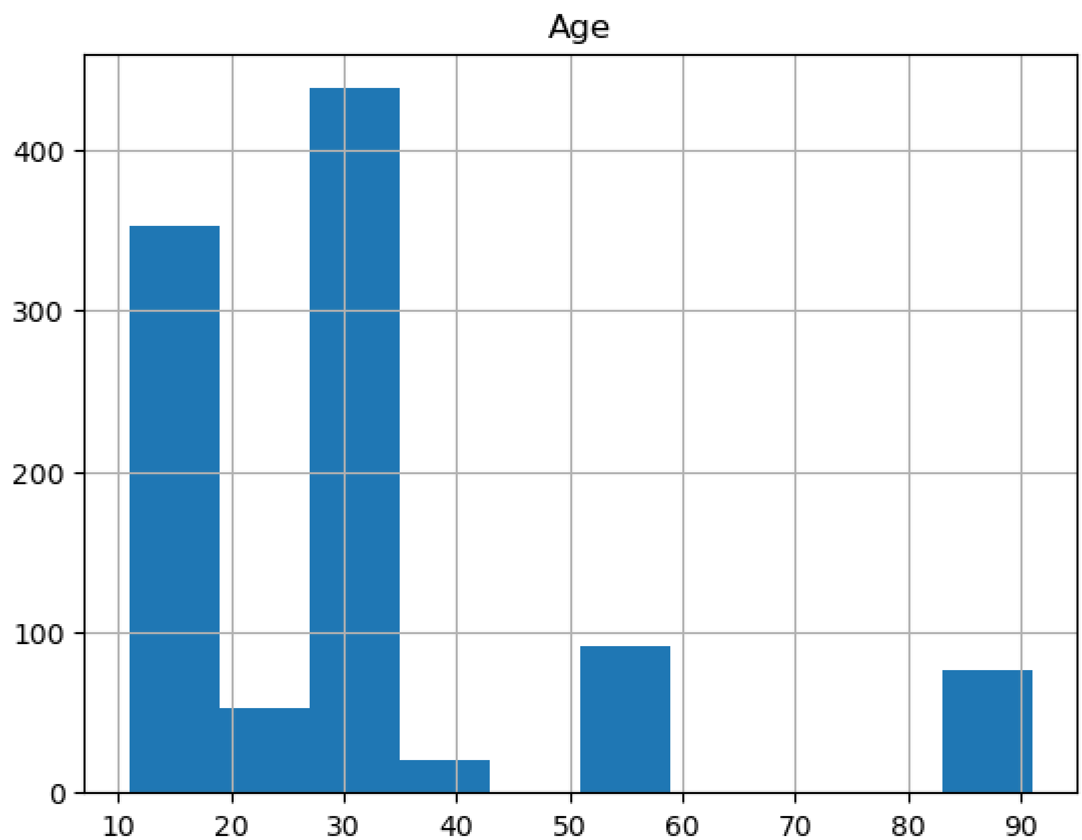
In [25]:
```python
data['Age'].value_counts()
```
Out[25]:
```
28    425
13    134
17    126
56     91
14     62
90     54
20     52
18     26
91     22
36     20
27     13
12      3
11      2
Name: Age, dtype: int64
```

In [26]:
```python
data
```
Out[26]:

	Cement	Blast Furnace Slag	Fly Ash	Water	Superplasticizer	Coarse Aggregate	Fine Aggregate	Age	Strength
0	540.0	0.0	0.0	162.0	2.5	1040.0	676.0	28	79.99
1	540.0	0.0	0.0	162.0	2.5	1055.0	676.0	28	61.89
2	332.5	142.5	0.0	228.0	0.0	932.0	594.0	27	40.27
3	332.5	142.5	0.0	228.0	0.0	932.0	594.0	36	41.05
4	198.6	132.4	0.0	192.0	0.0	978.4	825.5	36	44.30
...	...	...	...	...	...	...	...	...	..
1025	276.4	116.0	90.3	179.6	8.9	870.1	768.3	28	44.28
1026	322.2	0.0	115.6	196.0	10.4	817.9	813.4	28	31.18
1027	148.5	139.4	108.6	192.7	6.1	892.4	780.0	28	23.70
1028	159.1	186.7	0.0	175.6	11.3	989.6	788.9	28	32.77
1029	260.9	100.5	78.3	200.6	8.6	864.5	761.5	28	32.40

1030 rows × 9 columns

In [27]:
```
data.hist('Age')
pyp.show()
```



In [28]:
```
data.head()
```

Out[28]:

	Cement	Blast Furnace Slag	Fly Ash	Water	Superplasticizer	Coarse Aggregate	Fine Aggregate	Age	Strength
0	540.0	0.0	0.0	162.0	2.5	1040.0	676.0	28	79.99
1	540.0	0.0	0.0	162.0	2.5	1055.0	676.0	28	61.89
2	332.5	142.5	0.0	228.0	0.0	932.0	594.0	27	40.27
3	332.5	142.5	0.0	228.0	0.0	932.0	594.0	36	41.05
4	198.6	132.4	0.0	192.0	0.0	978.4	825.5	36	44.30

In [29]:
```python
x = data[['Cement','Superplasticizer','Age']]
x
```

Out[29]:

	Cement	Superplasticizer	Age
0	540.0	2.5	28
1	540.0	2.5	28
2	332.5	0.0	27
3	332.5	0.0	36
4	198.6	0.0	36
...	...	...	...
1025	276.4	8.9	28
1026	322.2	10.4	28
1027	148.5	6.1	28
1028	159.1	11.3	28
1029	260.9	8.6	28

1030 rows × 3 columns

In [30]:
```python
y = data['Strength']
y
```

Out[30]:
```
0       79.99
1       61.89
2       40.27
3       41.05
4       44.30
        ...
1025    44.28
1026    31.18
1027    23.70
1028    32.77
1029    32.40
Name: Strength, Length: 1030, dtype: float64
```

TRAINING MODEL

In [31]:
```python
xtrain,xtest,ytrain,ytest = train_test_split(x,y,test_size=0.2,random_state
```

In [32]:
```python
l_reg = LinearRegression()
```

In [33]:
```python
l_reg.fit(xtrain,ytrain)
```

Out[33]:
```
LinearRegression()
```

In [34]:
```
pred = l_reg.predict(xtest)
```

In [35]:
```
mean_squared_error(ytest,pred)
```

Out[35]: 135.85191393045255

EFFICIENCY OF TRAINED MODEL

In [36]:
```
mse = mean_squared_error(ytest,pred)
mean_y = y.mean()
r_squared = 1 - (mse / (mean_y ** 2))
print("Efficiency:", str(round(r_squared*100,2))+'%')
```

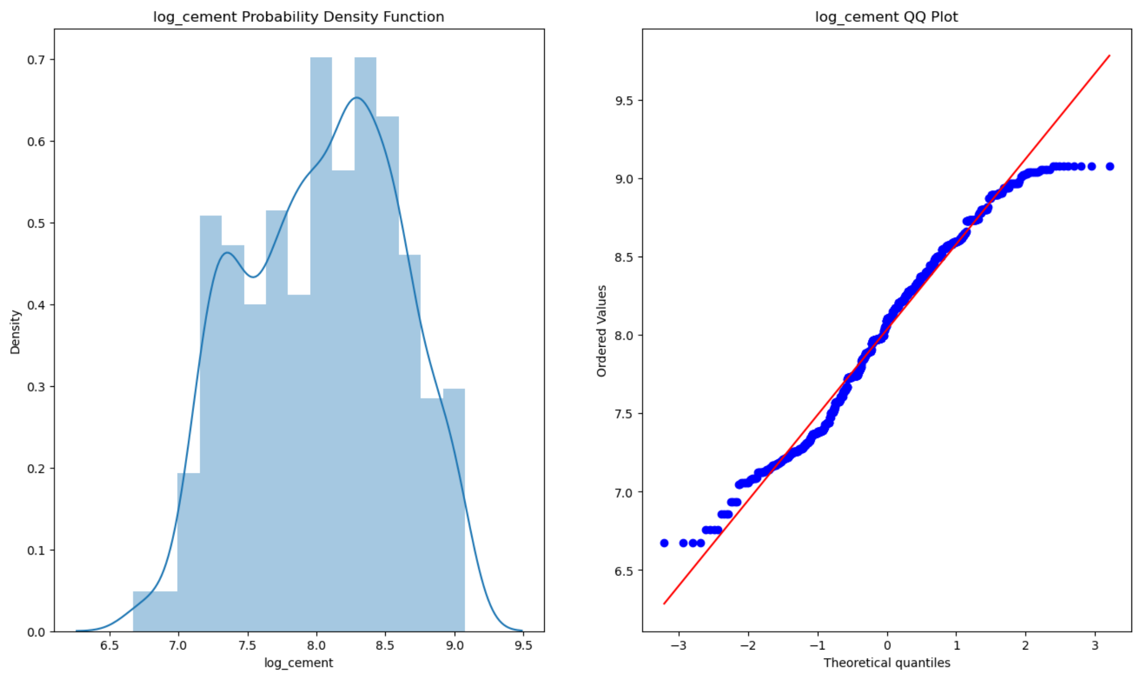
```
Efficiency: 89.41%
```

STANDARDISING FEATURES AND LABEL TO GET MORE EFFICIENCY

In [37]:
```
data['log_cement'] = np.log2(data['Cement'])
```

In [38]:

```
pyp.figure(figsize=(16,9))
pyp.subplot(121)
sns.distplot(data['log_cement'])
pyp.title('log_cement Probability Density Function')

pyp.subplot(122)
stats.probplot(data['log_cement'],dist='norm',plot=pyp)
pyp.title('log_cement QQ Plot')

pyp.show()
```



In [57]:

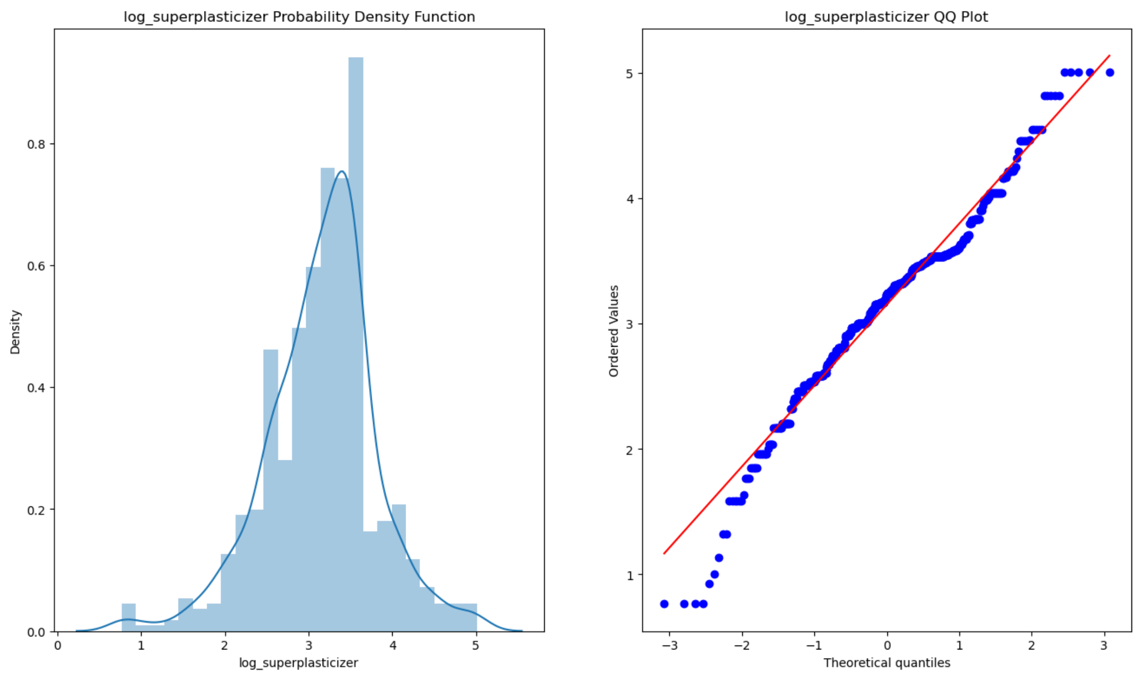
```
data.drop(data[data['Superplasticizer'] == 0].index,axis=0,inplace=True)
```

In [58]:

```
data['log_superplasticizer'] = np.log2(data['Superplasticizer'])
```

In [59]:

```
pyp.figure(figsize=(16,9))
pyp.subplot(121)
sns.distplot(data['log_superplasticizer'])
pyp.title('log_superplasticizer Probability Density Function')

pyp.subplot(122)
stats.probplot(data['log_superplasticizer'],dist='norm',plot=pyp)
pyp.title('log_superplasticizer QQ Plot')

pyp.show()
```

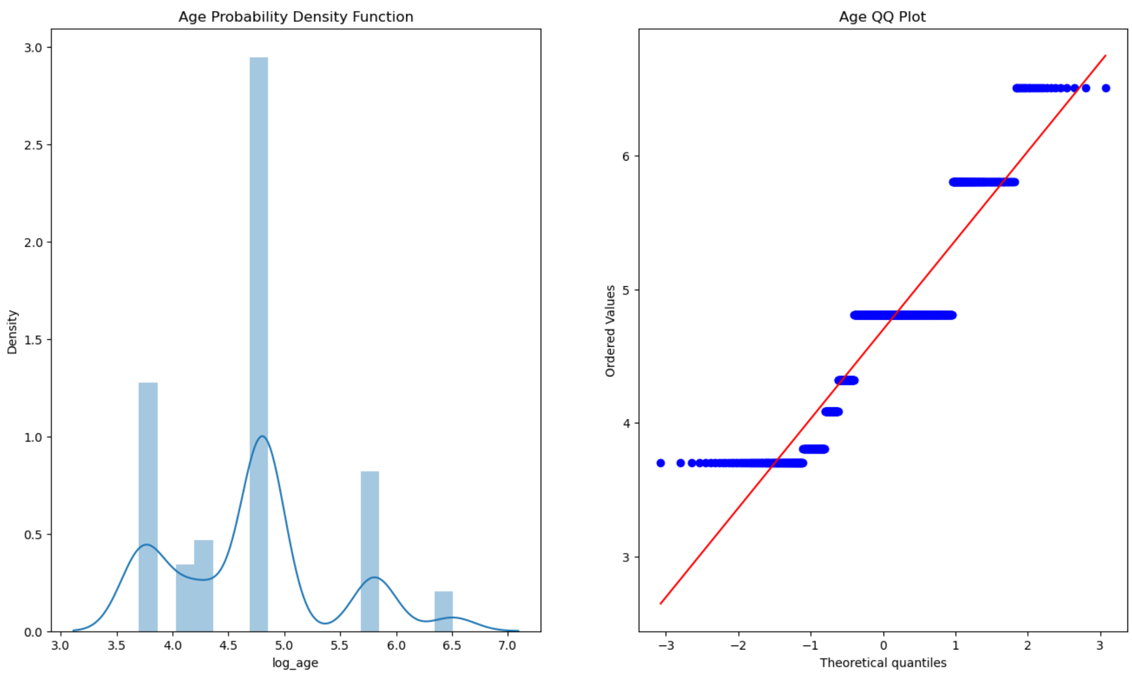


In [61]:

```
data['log_age'] = np.log2(data['Age'])
```

In [62]:

```
pyp.figure(figsize=(16,9))
pyp.subplot(121)
sns.distplot(data['log_age'])
pyp.title('Age Probability Density Function')

pyp.subplot(122)
stats.probplot(data['log_age'],dist='norm',plot=pyp)
pyp.title('Age QQ Plot')

pyp.show()
```



In [63]:

```
x = data[['log_cement','log_superplasticizer','log_age']]
x
```

Out[63]:

	log_cement	log_superplasticizer	log_age
0	9.076816	1.321928	4.807355
1	9.076816	1.321928	4.807355
70	8.546894	3.336283	3.700440
71	8.291401	3.104337	3.700440
72	8.731319	4.044394	3.700440
...	...	...	...
1025	8.110614	3.153805	4.807355
1026	8.331813	3.378512	4.807355
1027	7.214319	2.608809	4.807355
1028	7.313790	3.498251	4.807355
1029	8.027353	3.104337	4.807355

651 rows × 3 columns

In [64]:
```
y = data['Strength']
y
```

Out[64]:
```
0       79.99
1       61.89
70      34.40
71      28.80
72      33.40
        ...
1025    44.28
1026    31.18
1027    23.70
1028    32.77
1029    32.40
Name: Strength, Length: 651, dtype: float64
```

In [65]:
```
xtrain,xtest,ytrain,ytest = train_test_split(x,y,test_size=0.2,random_state
```

In [66]:
```
insurance_model = LinearRegression()
```

In [67]:
```
insurance_model.fit(xtrain, ytrain)
```

Out[67]:
```
LinearRegression()
```

In [73]:
```
ypred = insurance_model.predict(xtrain)
```

In [74]:
```
mean_squared_error(ytrain, ypred)
```

Out[74]:
```
119.04129998306546
```

In [75]:
```
mse = mean_squared_error(ytrain,ypred)
mean_y = y.mean()
r_squared = 1 - (mse / (mean_y ** 2))
print("Efficiency:", str(round(r_squared*100,2))+'%')
```

```
Efficiency: 92.36%
```