Package: tbsa (via r-universe)

September 9, 2024

Type Package

Title Turbine Blade Strike Analysis

Version 0.1.0

Author Travis Hinkelman

Maintainer Travis Hinkelman <thinkelman@esassoc.com>

Description R implementation of spreadsheet model provided by the USFWS for performing leading-edge blade strike analysis of hydropower turbines on fish.

License MIT + file LICENSE

Encoding UTF-8

LazyData true

RoxygenNote 7.1.2

Suggests tinytest

Depends R (>= 2.10)

Imports dplyr

Repository https://environmentalscienceassociates.r-universe.dev

RemoteUrl https://github.com/EnvironmentalScienceAssociates/tbsa

RemoteRef HEAD

RemoteSha 63eaeec9204c6881b9f74186da5db220d87130ef

Contents

`discharge_coef` *Discharge coefficient*

Description

Non-dimensional discharge coefficient term incorporated into strike equations

Usage

```
discharge_coef(Q, D, rpm)
```

Arguments

`Q`	Turbine discharge (cfs)
`D`	Nominal diameter (ft) of runner
`rpm`	Runner revolutions per minute

`energy_coef` *Energy coefficient*

Description

Non-dimensional energy coefficient term incorporated into strike equations

Usage

```
energy_coef(H, D, rpm)
```

Arguments

`H`	Net head on the turbine (ft)
`D`	Nominal diameter (ft) of runner
`rpm`	Runner revolutions per minute

`francis_alpha` *Francis alpha*

Description

Angle (rad) to tangential of absolute flow upstream of runner

Usage

```
francis_alpha(Q, H, D, D1, D2, rpm, eta, opt, xi, B)
```

Arguments

`Q`	Turbine discharge (cfs)
`H`	Net head on the turbine (ft)
`D`	Nominal diameter (ft) of runner
`D1`	Diameter (ft) at the intake of the runner
`D2`	Diameter (ft) at the outlet of the runner
`rpm`	Runner revolutions per minute
`eta`	Turbine efficiency
`opt`	Ratio of turbine discharge at best efficiency to hydraulic capacity
`xi`	Ratio between Q with no exit swirl and Qopt
`B`	Runner height (ft) at inlet

`francis_beta` *Francis beta*

Description

Relative flow angle (rad) at turbine discharge; used in strike equations

Usage

```
francis_beta(Q, D, D1, D2, rpm, opt, xi)
```

Arguments

`Q`	Turbine discharge (cfs)
`D`	Nominal diameter (ft) of runner
`D1`	Diameter (ft) at the intake of the runner
`D2`	Diameter (ft) at the outlet of the runner
`rpm`	Runner revolutions per minute
`opt`	Ratio of turbine discharge at best efficiency to hydraulic capacity
`xi`	Ratio between Q with no exit swirl and Qopt

francis_strike *Francis blade strike probability*

Description

Calculates leading-edge blade strike probability from a Francis turbine

Usage

```
francis_strike(Q, H, D, D1, D2, rpm, eta, opt, xi, B, N, L, lambda = 0.2)
```

Arguments

Q	Turbine discharge (cfs)
H	Net head on the turbine (ft)
D	Nominal diameter (ft) of runner
D1	Diameter (ft) at the intake of the runner
D2	Diameter (ft) at the outlet of the runner
rpm	Runner revolutions per minute
eta	Turbine efficiency
opt	Ratio of turbine discharge at best efficiency to hydraulic capacity
xi	Ratio between Q with no exit swirl and Qopt
B	Runner height (ft) at inlet
N	Number of blades
L	Fish length (ft)
lambda	Actual mortality correlation; influenced by many factors including unit type and fish species

kaplan_alpha *Kaplan alpha*

Description

Angle (rad) to tangential of absolute flow upstream of runner

Usage

```
kaplan_alpha(Q, H, D, rpm, eta, radius_ratio)
```

Arguments

Q	Turbine discharge (cfs)
H	Net head on the turbine (ft)
D	Nominal diameter (ft) of runner
rpm	Runner revolutions per minute
eta	Turbine efficiency
radius_ratio	r/R where R = 0.5 * D; passage near hub (0.5), mid-blade (0.75), blade tip (1)

---

kaplan_strike *Kaplan blade strike probability*

Description

Calculates leading-edge blade strike probability from Kaplan turbine

Usage

```
kaplan_strike(Q, H, D, rpm, eta, N, L, lambda = 0.2, radius_ratio = 0.75)
```

Arguments

Q	Turbine discharge (cfs)
H	Net head on the turbine (ft)
D	Nominal diameter (ft) of runner
rpm	Runner revolutions per minute
eta	Turbine efficiency
N	Number of blades
L	Fish length (ft)
lambda	Actual mortality correlation; influenced by many factors including unit type and fish species
radius_ratio	r/R where R = 0.5 * D; passage near hub (0.5), mid-blade (0.75), blade tip (1)

propeller_alpha *Propeller alpha*

Description

Angle (rad) to tangential of absolute flow upstream of runner

Usage

```
propeller_alpha(Q, H, D, rpm, eta, opt, radius_ratio)
```

Arguments

Q	Turbine discharge (cfs)
H	Net head on the turbine (ft)
D	Nominal diameter (ft) of runner
rpm	Runner revolutions per minute
eta	Turbine efficiency
opt	Ratio of turbine discharge at best efficiency to hydraulic capacity
radius_ratio	r/R where R = 0.5 * D; passage near hub (0.5), mid-blade (0.75), blade tip (1)

propeller_beta *Propeller beta*

Description

Relative flow angle (rad) at turbine discharge; used in strike equations

Usage

```
propeller_beta(Q, D, rpm, opt, radius_ratio)
```

Arguments

Q	Turbine discharge (cfs)
D	Nominal diameter (ft) of runner
rpm	Runner revolutions per minute
opt	Ratio of turbine discharge at best efficiency to hydraulic capacity
radius_ratio	r/R where R = 0.5 * D; passage near hub (0.5), mid-blade (0.75), blade tip (1)

`propeller_strike` *Propeller blade strike probability*

Description

Calculates leading-edge blade strike probability from a propeller turbine

Usage

```
propeller_strike(
  Q,
  H,
  D,
  rpm,
  eta,
  opt,
  N,
  L,
  lambda = 0.2,
  radius_ratio = 0.75
)
```

Arguments

`Q`	Turbine discharge (cfs)
`H`	Net head on the turbine (ft)
`D`	Nominal diameter (ft) of runner
`rpm`	Runner revolutions per minute
`eta`	Turbine efficiency
`opt`	Ratio of turbine discharge at best efficiency to hydraulic capacity
`N`	Number of blades
`L`	Fish length (ft)
`lambda`	Actual mortality correlation; influenced by many factors including unit type and fish species
`radius_ratio`	r/R where R = 0.5 * D; passage near hub (0.5), mid-blade (0.75), blade tip (1)

rand_route *Random route selection*

Description

Randomly select route for a fish through a project from a multinomial distribution based on routing probabilities.

Usage

```
rand_route(fish_num, route_names, route_probs)
```

Arguments

fish_num	Number of fish in the simulation
route_names	Vector of route names through a project
route_probs	Vector of probabilities that fish enters each route; should sum to one.

rotational_speed *Rotational speed*

Description

Rotational speed

Usage

```
rotational_speed(rpm)
```

Arguments

rpm	Runner revolutions per minute

route_data_ex *Example Route Data*

Description

Example route data used as input to the tbsa function. Includes all four route types and corresponds to the "Francis, Kaplan and propeller w spill, gates and bypass" example in the spreadsheet model.

Usage

```
route_data_ex
```

Format

A data frame with 9 rows and 16 variables:

route_name Unique name of a route through a project

route_prob Probability that a fish enters each route; should sum to one.

route_type Route type should be one of Francis, Kaplan, propeller, or bypass.

D Nominal diameter (ft) of runner

N Number of blades

B Runner height (ft) at inlet

Q Turbine discharge (cfs)

opt Ratio of turbine discharge at best efficiency to hydraulic capacity

H Net head on the turbine (ft)

rpm Runner revolutions per minute

xi Ratio between Q with no exit swirl and Qopt

lambda Actual mortality correlation; influenced by many factors including unit type and fish species

D1 Diameter (ft) at the intake of the runner

D2 Diameter (ft) at the outlet of the runner

eta Turbine efficiency

est_mortality Estimated mortality for routes without turbines, e.g., gates, spillways, fishways, etc.

tbsa *Turbine blade strike analysis*

Description

Runs stochastic simulation of turbine blade strike analysis based on input parameters in route_data

Usage

```
tbsa(fish_num, length_mean, length_sd, route_data)
```

Arguments

fish_num	Number of fish in the simulation
length_mean	Mean fish length (ft)
length_sd	Standard deviation of fish length (ft)
route_data	Data frame with input parameters for each route (see route_data_ex for example)

Examples

```
tbsa(10, 1.5, 0.25, route_data_ex)
```

Index